PROCEEDINGS

OF THE

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS

FOR INDIA.

SIXTH MEETING

HELD AT CALCUTTA, DECEMBER 1894.

VOL. VI.

SIMLA:

PUBLISHED BY THE TECHNICAL SECTION,

OFFICE OF CONSULTING ENGINEER FOR STATE RAILWAYS.

1895.

NOTICE.

It is to be understood that all decisions of the Committee as given in the following pages are subject to the approval or confirmation of the Agent, Boards of Directors, or other authorities for individual Railways, and of the Government of India in all cases.

GENERAL COMMITTEE.

CHAIRMAN

C T Sandiford *M Inst C E, M I Mech E*—
Locomotive and Carriage Superintendent
North Western Railway (5 ft 6 in gauge)

DEPUTY CHAIRMAN

C E Crighton, *M Inst C E*—
Locomotive and Carriage Superintendent,
South Indian Railway (Metre gauge)

MEMBERS

J J Adler,—
Acting Carriage and Wagon Superintendent
F N Gütersloh,—
Locomotive Superintendent
Rajputana Malwa Railway (Metre gauge)

J E Berkley, *M Inst C E., M I Mech E*—
Locomotive and Carriage Superintendent
Nizam's Railway (5 ft 6 in gauge)

L E H Brock,—
Locomotive and Carriage Superintendent
Indian Midland Railway (5 ft 6 in gauge)

C E Cardew, *Assoc M Inst C E M I Mech E*—
Locomotive and Carriage Superintendent
Burma Railway (Metre gauge).

E B Carroll, *M Inst C E*—
Locomotive and Carriage Superintendent
Bombay Baroda and Central India Railway (5 ft 6 in gauge)

A S Jameson—
Locomotive and Carriage Superintendent
Eastern Bengal Railway (5 ft 6 in and Metre gauges)

A Morton, *M I C E*—
Locomotive and Carriage Superintendent
East Coast Railway (5 ft. 6 in gauge).

R Pearce, *M I Mech E*—
Carriage and Wagon Superintendent
A W Rendell, *M Inst C E, M I Mech E*—
Locomotive Superintendent
East Indian Railway (5 ft 6 in gauge)

C E Phipps, *M Inst C E M I Mech E*—
Locomotive and Carriage Superintendent
Madras Railway (5 ft 6 in gauge)

A Rhind—
Locomotive and Carriage Superintendent
Bengal Nagpur Railway (5 ft 6 in gauge)

A E Ryles—
Locomotive and Carriage Superintendent,
Bengal and North Western Railway (Metre gauge).

R L Trevithick *Assoc M Inst C E*—
Locomotive and Carriage Superintendent
Great Indian Peninsula Railway (5 ft 6 in gauge)

C P Whitcombe *M Inst C E*—
Locomotive and Carriage Superintendent
Southern Mahratta Railway (Metre gauge)

G Winmill, *M I Mech E*—
Locomotive and Carriage Superintendent
Oudh and Rohilkhand Railway (5 ft 6 in gauge)

R Wylie,—
Locomotive and Carriage Superintendent
Bhavnagar Gondal Railway (Metre gauge)

SECRETARY

F Wolley-Dod—*Assoc M Inst C E Simla*

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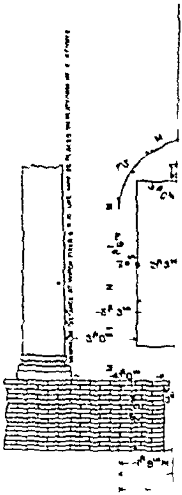
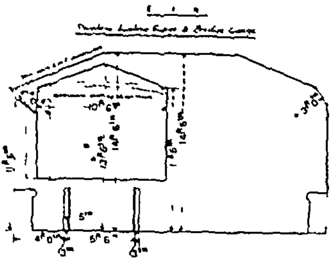
PLATES TO ILLUSTRATE PART IV.





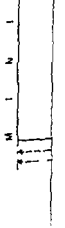
FAST INDIAN RAILWAY

Memorandum of certain Uniform Dimensions agreed upon with [illegible] the Indian Railways and sanctioned by the Hon'ble East India Company in the Despatch dated 5 March 1856

1	Minimum clear width between the tracks	6 feet	
2	Minimum clear distance of platform wall from rail	2 feet	6 inches
3	Projection of nosing not more than — — —		3 inches
4	Minimum clear height for all over openings above rails in centre of each line — — —	14 feet	6 inches
5	Goods loading guage for interchange of traffic to be settled to pattern		
6	Breadth from centre to centre of Buffers	[illegible]	[illegible]
7	Height of centre of Buffer above rail for all rolling stock to be hereafter constructed — —	3 feet	[illegible]
8	[illegible] for Carriages extreme width of body	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	
9	Length between [illegible] wheels of Carriages and Waggons maximum	[illegible]	
10	Minimum diameter of Turntables	[illegible]	
11	The [illegible] to turn [illegible] of diameter of — —	40 feet	
12	All Carriages and Waggons to have [illegible] and Draw springs at both ends		

GEORGE TURNBULL
Ch. of Engineer

Calcutta 6th June 1856



East India Railway House
[illegible] 26th December 1856

To

The [illegible] Agents of the East India [illegible]
Company [illegible]

Gentlemen

I am instructed by the Board [illegible]
to hand you enclosed for your guidance a tracing [illegible]
Gauge for interchange of Traffic on Railways [illegible]
been agreed upon by this Company the [illegible]
[illegible], the Central of India, and the [illegible]

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

PART I. — GENERAL PROCEEDINGS.

CALCUTTA—DECEMBER 1894.

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

GENERAL PROCEEDINGS, 1894.

SUB COMMITTEES FOR 1895 96

Locomotives

5 ft 6 in gauge	*Metre gauge*
A W Rendell (*Representative*)	C P Whitcombe (*Representative*)
L E H Brock	C E Crighton
C T Sandiford	F N Gutersloh

Weight of Locomotives and Rolling Stock

C T Sandiford (*Representative*)
E B Carroll
A W Rendell

Carriages and Wagons, including Military requirements

5 ft 6 in gauge	*Metre gauge*
R. Pearce (*Representative*)	C E Cardew (*Representative*)
C E Phipps	C E Crighton
C T Sandiford	C P Whitcombe

Automatic Vacuum Brake including Communication in Trains

E B Carroll (*Representative*)
C E Crighton
A S Jameson

Carriage Lighting

5 ft 6 in gauge	*Metre gauge*
E B Carroll (*Representative*)	C P Whitcombe (*Representative*)
R Pearce	J J Adler
R L Trevithick	C E Cardew

Workshops

5 ft 6 in gauge	*Metre gauge*
L E H Brock (*Representative*)	C E Crighton (*Representative*)
J E Berkley	C E Cardew
C E Phipps	C P Whitcombe

Carriage Examiners Rules and Break Down Trains

C E. Phipps (*Representative*)
J E. Berkley
C P Whitcombe

GENERAL PROCEEDINGS.

Date and place of Meeting—

The sixth General Meeting commenced on the morning of Monday, December 3rd, 1894, and lasted seven days, and was held in the Howrah Town Hall Calcutta, this room having been engaged at the joint charge of the East Indian and Eastern Bengal State Railways as neither Railway possessed in Calcutta a room convenient for the use of the Committee

Chairman—

The votes of the Members were taken under Rule 9 * the result of the election being as follows —

Chairman —Mr C T Sandiford Locomotive and Carriage Superintendent, North Western Railway

Deputy Chairman —Mr C E Crighton Locomotive Superintendent South Indian Railway

Members—

The following table, showing the Members of the Committee and the number of votes allotted to each under Rule 12,† was agreed to as correct —

Name of Member	Railway represented	Stock represented on 1st October 1894. Axles	Locos	Equivalent Total Axles	Votes
Adler J J Gutersloh F N	Rajputana Malwa	20 709	430	42 209	7
Berkley J E	Nizam s	1 833	50	4 333	2
Brock L E H	Indian Midland	5 163	117	11 013	4
Cardew C E	Burma	9 791	140	16 791	4
Carroll E B	Bombay Baroda and Central India	10 151	155	17 901	4
Crighton C E	South Indian	8 945	206	19 245	4
Jameson A S	Eastern Bengal	10 637	183	20 087	5
Morton A	East Coast	2 080	38	3 980	2
Pearce R Rendell A W	East Indian	23 157	596	5[illegible] 957	8
Phipps C. E	Madras	7,2[illegible]9	163	15,4[illegible]9	4
Rhind A.	Bengal Nagpur	7 [illegible]41	112	13,341	4
Ryles A E	Bengal and North Western	6 592	100	11 592	4
Sandiford, C T	North Western	[illegible]6 946	605	57 1[illegible]	8
Trevithick, R L	Great Indian Peninsula	19,4[illegible]	605	49[illegible]	7
Whitcombe C. P	Southern Mahratta	11 6[illegible]	[illegible]	22,6[illegible]	5
Wimmill G	Oudh and Rohilkhand	10,0[illegible]8	[illegible]7	1[illegible]3	4
Wylie, R.	Bhavnagar-Gondal	[illegible]3[illegible]	33	3,[illegible]	2

* Old rules. This is now section 4 of the Bye-laws.

† Old rules. Now section 7 of the Bye-laws.

Attendance at Meeting — Rules for Expenditure — General Rules — By Laws

The number of votes was the same as at last meeting except in the case of the Eastern Bengal State Railway which now has five votes instead of four, and the East Coast Railway, having more than 300 miles of line open for traffic, is now entitled to representation by Mr A Morton who was however unable to attend the meeting

Messrs J E Berkley, of the Nizam s Guaranteed A Morton, of the East Coast, and R Wylie of the Bhavnagar Gondal were absent on leave and these railways were not represented at the meeting

Owing to changes in their staff or assistants being on leave Messrs L E H Brock of the Indian Midland E B Carroll of the Bombay Baroda A Rhind of the Bengal Nagpur, and R L Trevithick of the Great Indian Peninsula were unable to attend

Rules for Expenditure—

The rules sanctioned under Government of India, Public Works Department, Circular No 168 R S dated 4th May 1894, and printed in Volume V, page 139, and the by laws in connection with the same were read (*see pages 10 and 14 in this volume*)

The following amounts which had been sanctioned during the year were recorded these sanctions lapsed on the 3rd December 1894—

		Rs
1	Mr E B Carroll for preparing drawings of boiler mountings, carriage fittings workshop roof and bogie carriages	325
2	Mr C E Cardew for drawings in connection with the reports of Metre gauge Carriage and Wagon Sub Committee	750
3	Mr C P Whitcombe for drawings to illustrate the reports of the Metre gauge Sub Committee for locomotives	1,200
4	Mr R Pearce, for drawings to illustrate the report of the 5 ft 6 in gauge Sub Committee for carriages and wagons	600
	TOTAL	2 875

General Rules—

The revised general rules sanctioned under Government of India, Public Works Department Circular No 353 R S, dated 16th October 1894, were read

With reference to rule 8 it was **Resolved** that the Secretary submit to the Government of India a proposal to hold meetings once in every two years only, (*this was accepted by the Government of India in letter No 137 R S, dated 8th May 1895, and the rules as thereby modified are printed at page 7 in this volume*) that in alternate years when no meeting is held the reports of the Sub Committees and other subjects to be brought forward for discussion, be submitted in the same way as when a meeting is held, and circulated to all members for opinion in accordance with the rules for ballot vote, only points which are not thus settled, and either approved or rejected by less than two thirds of the total votes available, to be reserved for discussion at the next meeting

By-Laws—

A draft was read and discussed, it was **Resolved** that they be altered to suit the above Resolution

Sub-Committees — Workshops — Place of next meeting — Reprint of Business Transacted.

A copy of the By-Laws as modified is given on page 13. These are based on the previous Rules and Subsidiary Rules, one or two points not hitherto provided for have been included, the most important of these is that a brief statement of all matter to be brought forward shall be sent to the Secretary not later than 15th September, to enable him to have this printed and distributed to all members two months before the meeting.

Sub-Committees—

The Sub-Committees appointed to carry on the work till next meeting are shown on page 3 These are the same as for last year, except that a special Sub-Committee has been appointed to consider the question of weights of Locomotives and Rolling stock, the special Sub-Committee for wheels has been dissolved, and Mr. C. E. Cardew has been elected in place of Mr. R. Wylie on the Workshops Sub-Committee.

Visits to Workshops, &c.—

On the afternoon of Wednesday, the 5th December, the members of the Committee visited the Carriage and Wagon Workshops of the East Indian Railway at Howrah under the guidance of Mr. R. Pearce, the Carriage and Wagon Superintendent.

On the morning of Thursday, the 6th December, the members visited the Locomotive and Carriage and Wagon Workshops of the Eastern Bengal State Railway at Kanchrapara, under the guidance of Mr. A S. Jameson, the Locomotive and Carriage and Wagon Superintendent, travelling from Sealdah station to Kanchrapara and back by special train, kindly provided by the Manager of that Railway.

After the close of the meeting a few of the members proceeded to Jamalpur

Page 6.

Place for next Meeting—

Mr L E H. Brock, the Locomotive Superintendent of the Indian Midland railway, subsequently gave notice that he would probably be absent on furlough in December 1896. It was therefore decided that the next meeting should be held on the Southern Mahratta railway, at either Hubli or Dharwar, whichever would be most convenient to the authorities of that railway.

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After the close of the meeting a few of the members proceeded to Jamalpur to inspect the Locomotive Workshops of the East Indian Railway under the guidance of Mr A W Rendell, the Locomotive Superintendent

These employ about 5 000 workmen and in addition to the usual Loco repairs manufactures for all departments are conducted on a large scale The Rolling Mill contains three high mills of which two, 10 in and 14 in, are working and one 16 in mill is in course of construction, the present outturn of the two mills being 4 000 to 5 000 tons per annum of merchant bars, sleeper tie bars, fish plates etc The Bolt and Nut Machine Department turns out about *1,100 000 bolts, nuts, rivets and spikes per annum* The Foundry turns out about 16 000 tons of castings of all descriptions per annum, using 10 000 tons of Indian pig and nothing but Indian coke *a large percentage of this outturn is* permanent way material In the Points Crossings and Signals Department a large circular saw is employed for cutting off worn ends of rails operating on both ends of six rails at once Extensions are in progress for building locomotives entirely instead of importing them

Place for next meeting—

It was decided that, subject to the approval of the authorities of the Indian Midland Railway, the next ordinary meeting be held at Jhansi, the head-quarters of that railway

Reprint of Business Transacted—

A reprint of Business Transacted and Resolutions Adopted on the various subjects at the first five meetings was distributed to members, and the arrangement of these in seventeen subjects under different sub-heads approved

GENERAL RULES, 1894.

Sanctioned by Government of India, P W. D, No 353 R S, dated 16th October 1894, in supersession of those sanctioned in P. W D No 107 R S, dated 18th July 1891 (The alterations made by P. W. D No 137 R S, dated 8th May 1895, are entered in italics)

The Constitution of the Committee—

1 The Committee shall be called "The Committee of Locomotive and Carriage Superintendents for India"

2 The functions of the Committee shall be to discuss matters relating to the mechanical improvement of Locomotives or Carriage and Wagon Stock, the design, construction, running and repair of the same, and the standards to be adopted, to arrange for such experiments as may appear desirable, to publish papers of professional interest, and generally to consider and report upon all technical, administrative, or financial questions connected with Rolling Stock, Workshops, Station Machinery, etc, which may be proposed by the members themselves, by any railway administration, or by the Consulting Engineer to the Government of India

3 The Chief Locomotive or Carriage Officer of every railway in India, having a length of not less than 300 miles open for traffic shall be *ex officio* a member of the Committee In the absence of the permanent incumbent the officer appointed to officiate for him shall take his place on the Committee

4 The Chairman and Deputy Chairman shall be elected by the members They shall each hold office *till the next general meeting*, and shall be eligible for re election any number of successive years

5 The Secretary shall be appointed and paid by the Government of India His duties shall be to conduct the management of the general business of the Committee under the orders of the Chairman subject to such instructions as he may receive from the Consulting Engineer to the Government of India The Secretary shall have no vote and shall not be a member of the Committee

6 Work done by the Secretary, such as printing and distributing papers, copies of the Proceedings, Index Working Drawings General Directory and Rules and By laws will be at the expense of the Government of India

Distribution of Expenditure—

7 Expenditure other than that provided for in Rule 6 will be distributed in accordance with Government of India, Public Works Department, Circular No 168 R S of 4th May 1894 *(see appendix A, page 10)*

General Rules

Meetings—

8 *The meetings of the Committee may, with the approval of the Government of India, be held not oftener than once in two years* The word " meeting " shall be held to mean the entire period during which the members of the Committee are assembled in one neighbourhood for the purpose of transacting business

The Proceedings—

9 Immediately after *a general* meeting, the Secretary shall take steps to have the Proceedings printed and issued with the least practicable delay To members of the Committee a copy of each part of the Proceedings shall be issued separately as soon as printed

10 The Proceedings of the Committee shall be printed on foolscap size paper, and shall be arranged in five parts, each distinct and complete in itself, *viz* —

I —*General Proceedings* —Containing a record of the resolutions adopted on subjects connected with the constitution of the Committee, arrangements for work, and miscellaneous or personal matters

II —*Business Transacted* —Containing a record of resolutions adopted by the Committee on subjects brought forward for consideration or opinion

III —*Notes and Correspondence* —Containing miscellaneous memoranda and correspondence referred to in the Proceedings or connected with subjects brought forward for consideration

IV —*Selected Papers* —Containing papers of professional interest or importance either contributed by the members, or reprinted or compiled from other sources not generally accessible

V —*Plates* —Containing illustrations connected with any of the foregoing subjects, plates to be the size of a foolscap page

The five parts shall be half bound in one volume in a style similar to the volumes already issued

10 (*b*) *In years when no meeting is held, the Secretary will issue an ad interim report, showing all standards agreed to by ballot vote since the last meeting*

10 (*c*) A general Index of all the volumes shall also be brought up to date *periodically* and published in paper covers

Working drawings—

11 In addition to the small plates illustrating the Proceedings working drawings and diagrams of designs accepted by the Committee will be published These will be lithographed or photozincographed, and the size will be either double elephant (40 in × 27 in) or open foolscap (17 in × 13½ in), according to subject

General Directory—

12. The Secretary shall, as early as practicable each year, publish a General Directory and Railway List corrected up to the forenoon of the 1st January, giving a list of officers on the General Committee and Sub-Commitees, the names and addresses of all Locomotive and Carriage Officers in India; also statements showing for each railway, its length in miles, amount of stock, the names and service of officers, and other information

Issue of Proceedings, etc —

13 The bound copies of the Proceedings and the Index shall be issued in accordance with Government of India, Public Works Department, Circular No 103 R. S, of 12th March 1894, as corrected by Government of India No. 155 R S., dated 30th April 1894, and the other publications in accordance with Government of India, Public Works Department, Circular No 284 R S., of 18th August 1894, *copies of the ad-interim report will be issued in accordance with paragraph 4 of P W D No 284 R S., dated 18th August 1894* (*see appendix B, page 11*)

By-Laws—

14 The Committee are empowered to make such By-laws for the conduct of business as may from time to time appear desirable. These By laws shall be brought up to date *periodically* and printed

Alterations to Rules—

15 An alteration or addition to these General Rules shall not be made unless such alteration or addition be desired by at least two thirds of the members of the Committee and approved by the Government of India

Authority of decisions of Committee—

16 All decisions recorded by the Committee shall be understood to be subject to the approval or confirmation of the Agents, Boards of Directors, or other authorities for individual railways, and of the Government of India in all cases, *vide* Government of India, Public Works Department, letter No 115 R S, dated 22nd March 1894, to the Director General of Railways, copy attached (*see appendix C, page 12*).

APPENDIX A.

RULES FOR EXPENDITURE

Copy of Government of India, Public Works Department, Circular No 168 R S, dated Simla the 4th May 1894

The amended draft rules for dealing with such expenditure as may be incurred in connection with the work of the Committee of Locomotive and Carriage and Wagon Superintendents in India which were circulated with Government of India letter No 106 R S, dated 15th April 1893, having been accepted by the administrations of the railways noted below, I am now directed to convey the formal sanction of the Government of India to the adoption of the rules

East Indian	Madras.	Kolhápur
Bengal Nagpur	Nizam's Guaranteed State	Mysore
Indian Midland.	Bengal and North Western	Jodhpore Bickaneer
North Western	Rohilkhand and Kumaon	Bhavanagar Gondal Junagarh Porbandar
Oudh and Rohilkhand.	Southern Mahratta	Jorhat
Eastern Bengal	South Indian	Darjeeling Himalayan
East Coast	Assam Bengal	Cherra Companyganj
Great Indian Peninsula	Burma State	
Bombay Baroda and Central India.	Dibru Sadiya	

2 A copy of the rules as approved is attached

Rules for dealing with expenditure which may be incurred in connection with the work of the Committee of Locomotive and Carriage and Wagon Superintendents in India

1 The charges noted below will be debited, as incurred, to one head, and the total will be divided annually (at the end of each official year) amongst the railways interested the share borne by each railway being in proportion to its mean open mileage for the year —

(*a*) Cost of office establishment specially entertained for the work of the Committee

(*b*) Any special expenditure incurred with the sanction of Government for a particular object which the Committee decides is of sufficient importance to all the railways concerned (*e g*, experiments with brakes, experiments with petroleum as fuel etc etc)

2 The charges noted below will be borne by the railway in whose service the member of the Committee by whom the expenditure was incurred happens to be—

(*a*) Travelling allowances of a member to attend a general meeting or meeting of his sub committee

(*b*) The cost of models or other work done on the order of an individual member in his own workshops or elsewhere

(*c*) Stationery and office expenses generally (except establishment)

(*d*) Experiments of minor importance for which it is not considered worth while to apply for sanction under 1 (*b*)

(*e*) Expenses incidental to the preparation of the Committee room for a general meeting and other arrangements connected with the meeting

3 The Chairman will be recognized as the authority by whom establishment required by a member is to be sanctioned

4 The accounts of expenditure under rule 1 will be kept by the Examiner of Accounts, State railway stores, Simla, in correspondence with the local Examiners or Auditors of individual railways, and in communication with the Secretary to the Committee.

General Rules

APPENDIX B

ISSUE OF THE PROCEEDINGS OF THE COMMITTEE

Copy of Government of India, P W D, Circulars Nos 103 and 155 R S, dated 12th March and 30th April 1894

The question of the distribution of the Proceedings of the Committee of Locomotive and Carriage and Wagon Superintendents having been raised, the Government of India are pleased to sanction the following rules for the guidance, in future, of the Secretary to the Committee who will distribute copies of the Proceedings, free of charge, as soon as they are ready for issue as follows —

(a) Each member of the Committee to be supplied with one copy of the Proceedings as his own property

(b) Agents of Guaranteed and Assisted Railways to be supplied with—

1 copy for transmission to their Boards of Direction,

2 copies for the use of the Railway Administration

1 copy for the office of the Locomotive Superintendent of the line, and

1 copy for the office of the Carriage and Wagon Superintendent if a separate officer

(c) Managers of State Railways to be supplied with—

2 copies for the use of the Railway Administration

1 copy for the office of the Locomotive Superintendent of the line, and

1 copy for the office of the Carriage and Wagon Superintendent if a separate officer

(d) Local Administrations and the Consulting Engineers having control of railways to be supplied each with 1 copy for office record

(e) The Director General of Railways to be supplied with 10 copies* one of which will be transmitted to the Director General of Stores for the use of the Consulting Engineer at the India Office

(f) 12 copies to be retained by the Secretary to the Committee for issue to Societies and individuals at his discretion

2 Copies when available will be issued on sale to the general public by the Superintendent Government Printing Calcutta, at a price of Rs 7 8 per copy

Copy of Government of India P W D Circular No 284 R S dated 18th August 1894

In continuation of letter No 103 R S of 12th March 1894 the Government of India are pleased to direct that the Index of the Proceedings, General Directory and By laws of the Committee of Locomotive and Carriage and Wagon Superintendents be issued in the same way as the Proceedings

2 Any one purchasing a copy of the Proceedings will be entitled to one copy of the Index free

3 The General Directory, when available, will be issued to the public at a price of one rupee per copy Copies of the By laws will not be for sale

4 One copy of each working drawing will be supplied free to each Member of the Committee, two copies to the Agent or Manager of each Railway represented on the Committee and 10 copies* to the Director General of Railways and copies will be on sale to the general public at a price to be fixed separately for each drawing

* This number has since been increased to 11 copies two being sent to the Director General of Stores

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1 copy for the office of the Carriage and Wagon Superintendent if a separate officer

(d) Local Administrations and the Consulting Engineers having control of railways to be supplied each with 1 copy for office record

(e) The Director General of Railways to be supplied with 10 copies* one of which will be transmitted to the Director General of Stores for the use of the Consulting Engineer at the India Office

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In continuation of letter No 103 R S of 12th March 1894 the Government of India are pleased to direct that the Index of the Proceedings, General Directory and By-laws of the Committee of Locomotive and Carriage and Wagon Superintendents be issued in the same way as the Proceedings

2 Any one purchasing a copy of the Proceedings will be entitled to one copy of the Index free

3 The General Directory when available, will be issued to the public at a price of one rupee per copy Copies of the By laws will not be for sale

4 One copy of each working drawing will be supplied free to each Member of the Committee, two copies to the Agent or Manager of each Railway represented on the Committee and 10 copies* to the Director General of Railways, and copies will be on sale to the general public at a price to be fixed separately for each drawing.

* This number has since been increased to 11 copies two being sent to the Director General of Stores

General Rules.

APPENDIX C.

RECOGNITION BY THE GOVERNMENT OF INDIA OF THE RECOMMENDATIONS OF THE COMMITTEE.

Letter from the Secretary to the Government of India, Public Works Department to the Director General of Railways, No 115 R S, dated the 22nd March 1894

The attention of the Government of India has recently been invited to the desirability of recognizing in a more definite manner than has been done hitherto the recommendations and proposals set forth in their Resolutions by the Committee of Locomotive and Carriage and Wagon Superintendents, to the permanent constitution of which the Government of India gave their approval in their letter No 107 R S, dated 18th July 1891, and I am accordingly directed to communicate to you the following observations

2 The subjects treated of in Resolutions of the Committee fall generally under three heads —

(i) Those on which the Government of India are empowered in the Indian Railways Act IX of 1890 to issue orders to all railways

(ii) Those on which the Government of India are in a position to issue orders to most of the railways in India under the terms of their contract agreements

(iii) Those on which the Government of India can issue orders only, in an executive capacity, to State Railways

3 Under the first category will fall all questions in which the safety of the travelling public is concerned, and in regard to them I am to say that all possible weight will be attached to any Resolution of the General Committee when the subject with which it deals is under the consideration of the Government of India

4 The second category will comprise matters in which it is desirable in the interests of economy, efficiency, and general convenience, that the maximum of uniformity should be attained, and in regard thereto Government of India will endeavour to concert measures in communication with the Boards of the several railways with a view to expediting orders on the subjects of such Resolutions At the same time they consider that the members of the Committee should themselves take the initiative by moving their respective Agents to obtain the confirmation of the Proceedings by their Boards of Direction

5 It should be understood with regard to both categories (i) and (ii) that whenever an expression of opinion by the Government of India on any Resolution is desired, the fact should be specially recorded in that Resolution

6 The third category will include a large number of questions generally similar to those in the second, but in regard to which the attainment of uniformity while in itself desirable on like grounds is not of such importance as to call for any interference on the part of the Government of India, and which it is left to the individual administrations to deal with in accordance with the united expression of opinion on the part of the Committee

7 In conclusion I am to say that the functions of the Committee are clearly defined in Rule 2* of the rules sanctioned in Government of India letter No 107 R S, dated 18th July 1891, and further that any proposals which may materially affect the standard dimensions laid down for each gauge should be made only by the General Committee after very careful consideration of the matter in all its bearings, and not merely as affecting the carrying capacity, &c, of rolling stock

* The wording of this has been slightly modified in the new rules.

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

BY-LAWS, 1894.

1. Meetings

(*a*) The first sitting of an ordinary meeting shall be held on the forenoon of the first Monday in December at such place as the Committee may decide, and the place of meeting shall be changed each year

(*b*) In alternate years when no meeting is held, the same procedure is to be followed in submitting reports, bringing forward subjects for discussion, etc, as in the years when meetings are held, and each question will be submitted to ballot vote in accordance with section 10. Any proposal which is then approved or rejected by not less than two thirds of the total votes available under sections 5 and 7 shall be considered as finally approved or rejected, and only those proposals for which two-thirds of the available votes are not recorded either for or against shall be resubmitted for discussion at the next meeting

(*c*) Any member who may find himself unable to attend a meeting, should signify his inability to do so to the Secretary before the 15th November, and shall be asked to give his reasons for not being able to attend

Note —In most cases members inform the Secretary only at the last moment and either give no reason at all, or plead press of work the latter being hardly sufficient explanation unless it is stated how such press of work arose at the particular time fixed for the meeting Unless the Committee know fully the reasons which prevent members attending they are not in a position to suggest any remedy with a view to securing *a larger attendance*

(*d*) No person who is not a member of the Committee, except the Secretary, shall be allowed in the room in which the meetings are held during any part of a discussion, without the permission of the Chairman, or, in his absence, of the Deputy Chairman

2. Exhibition of Models, etc.

(*a*) Any one, not being a member of the Committee who wishes to exhibit at a meeting any model, sample, or drawing, should apply in writing to the officer who arranges to provide the room for the meeting Applications may be addressed to the Secretary, who will forward them to the officer concerned

(*b*) The officer who arranges to provide the room for the meeting will use his own discretion in allotting space to exhibitors, or in rejecting applications

(*c*) Every model, sample, or drawing sent for exhibition shall be considered as having been presented to the Committee, unless the sender states in writing at the time it is sent that it is not his intention to present it to the Committee.

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(*c*) Every model, sample, or drawing sent for exhibition shall be considered as having been presented to the Committee, unless the sender states in writing at the time it is sent that it is not his intention to present it to the Committee

(*d*) Every model, sample, or drawing exhibited, which is not presented to the Committee, shall be at the owner's risk, and the owner shall remove the same at the close of the meeting, or, if called upon to do so, at any time before the close of the meeting

(*e*) A copy of this rule shall be sent to every applicant for permission to exhibit

3 Expenditure

(*a*) Special office establishment entertained for work to be done for the Committee will be allowed only in cases where a member is authorized by the Committee to undertake such work on its behalf

(*b*) A member requiring special office establishment for work to be done by him for the Committee, will submit to the Chairman a statement *in the form in appendix A*, showing briefly the nature of the work to be done, the establishment wanted, the cost per mensem, the number of months for which the sanction is desired, and total cost

(*c*) Such applications should, where practicable, be submitted to the Chairman at a regular meeting, to enable him to consult the other members with reference to any point on which he may desire to obtain the opinion of the Committee

(*d*) An application for special office establishment exceeding Rs 1,000 in a year for any one Sub-Committee will be circulated by the Chairman to the members of the Committee for vote, the votes being by axles under Rule 7 All other applications will be disposed of by the Chairman on his own authority, unless he desires, in case of doubt, to refer the matter to the Committee

(*e*) Each application is to be submitted to the Chairman in triplicate, and, if agreed to, will be signed by him, two copies being returned by him to the applicant, and one copy sent to the Secretary for communication to the Examiner, State Railway Stores One copy will be retained for reference by the member making the application, and the other copy will be forwarded by him officially for information to the Auditor or Examiner of Accounts for his Railway

(*f*) A sanction granted under these rules shall be recorded in the next issue of the Proceedings and shall lapse on the forenoon of the first day of the next ordinary meeting, savings on a sanction accorded on one application cannot be utilized to supplement deficiencies under another application.

4 Chairman and Deputy Chairman

(*a*) At an ordinary meeting, the election of Chairman and Deputy Chairman shall take place before any other business is entered upon

(*b*) A list of the members of the Committee shall be handed to each member present, who shall, on his copy of the list, mark three votes against the name of the officer he recommends for Chairman, and two votes against the name of the officer whom he would next recommend, leaving the other names blank A member may not enter votes against his own name, and each voting paper shall be signed by the voter

(*c*) The Secretary shall take charge of the voting papers, and announce the name of the member who has gained the highest number of votes, who shall be Chairman, and also the name of the member who has gained the next highest number, who shall be Deputy Chairman

(*d*) Should the Chairman be absent during any part of the period for which he has been elected the Deputy Chairman shall take his place during such absence

By-Laws.

5. General Proceedings.

Part I of the Proceedings shall contain a record of subjects connected with the constitution of the Committee, arrangements for work, and miscellaneous or personal matters; on such subjects each member shall have one vote. Should the votes on any such question be equally divided, the Chairman or, if he be absent, the Deputy Chairman shall have a casting vote.

6. Business Transacted.

(*a*) Part II of the Proceedings shall contain a record of all resolutions adopted by the Committee on professional subjects brought forward for their consideration or opinion, together with a brief record of the proposals brought forward, the reasons for or against any proposal, and, in all cases where the opinion of members is not unanimous, the reasons for adopting any resolution.

(*b*) All resolutions recorded shall be understood to represent the general opinion of the Committee as a whole, and the dissent of individual members from resolutions agreed to by the General Committee shall be briefly recorded in part II only in cases in which a special request to that effect is made

(*c*) Designs accepted by the Committee shall, for convenience of reference, be divided into three classes, *viz.*—

1. *Absolute Standards.*
2. *Provisional Standards*
3. *Approved Designs.*

(1) The term 'Absolute Standard' shall mean a design or dimension the general adoption of which is prescribed by a Government order The Committee will from time to time recommend designs or dimensions the general adoption of which is considered of sufficient importance to warrant their being classed as 'Absolute Standards.'

The adoption of an 'Absolute Standard' is not intended to have retrospective effect so as to condemn existing stock which does not comply with it, unless a special recommendation to this effect is made by the Committee.

Examples—Coupling for Vacuum Brake Connections—Dimension centre to centre of buffers for 5 ft 6 in. gauge stock

(2) The term 'Provisional Standard' shall mean a design or dimension which is recommended by the Committee for general adoption, but which is not sufficiently well established (or perhaps not of sufficient importance) to warrant its being classed as an 'Absolute Standard' Designs or dimensions classed as 'Provisional Standards' will be gradually introduced as opportunity occurs, and will be worked to in new stock, and also as far as practicable in existing stock when making repairs.

With a view to a gradual increase in uniformity of practice and the introduction of standard parts and details which shall be alike and interchangeable on all railways, certain designs or dimensions which have become well established as 'Provisional Standards' will from time to time be recommended for adoption as 'Absolute Standards'

Examples—Cross Section of body for Coaching Stock—Length of underframe for each class of vehicle.

(3) The term 'Approved Design' shall mean a design or pattern approved by the Committee as a good example of the best practice in India up to date An 'Approved Design' may be for a vehicle as a whole or for a portion or detail of the same For any particular class of vehicle there may be several designs on the 'approved' list, each design having been selected as specially well suited to certain purposes or conditions of traffic.

From time to time fresh designs will be added to the 'approved' list, and designs which may be superseded will be removed. Thus, it is expected that by degrees the number of different types or patterns on Indian railways will be reduced, inferior or obsolete designs will gradually be eliminated, and *each* line in India will conform more nearly to the practice which, by common consent of *all* lines, has been determined to be the best.

7 Votes on Professional Subjects

(*a*) On questions having reference to professional subjects, the votes allotted to each railway shall depend on the amount of its stock for each gauge separately as follows —

Two votes for any number of axles not exceeding 5,000

Three votes for a number of axles exceeding 5 000, but not exceeding 10,000

One vote for each 10,000 axles, or part thereof, over and above 10,000, subject to a limit of eight votes for any one railway

(*b*) The word 'axles' shall mean axles belonging to coaching or goods stock in India either running, under repair, or in course of construction Spare axles are not to be reckoned One locomotive is to be considered as equivalent to fifty axles The stock of any railway for each gauge shall include the stock belonging to a line of that gauge worked by, or having its Locomotive or Carriage Department administered by the Superintendent of, that railway

(*c*) The number of votes allotted to a railway, at an ordinary meeting, shall be reckoned on the amount of stock in India on the first day of October immediately preceding such meeting In the case of a special meeting, the votes shall be reckoned on the stock in India on the first day of the quarter in which the meeting is held

(*d*) Where there are two representatives of the same railway—owing to there being a separate officer in charge of its Carriage and Wagon Department—the two members representing that railway shall settle between themselves upon what subject each shall vote, or in what way they shall divide the votes, so that the votes for that railway may not be counted twice over

(*e*) Subject to the restriction that the full number of votes for any railway may only be used once, each member shall be at liberty to record his opinion on any question that may arise even though such question may not affect railways on the gauge of the line represented by such member, but he shall not have a vote on any subject in which the gauge of the line he represents is not interested

8 Votes of Members absent

(*a*) A member of the Committee being unable to attend during any portion of a meeting may nominate another member to vote for him during such absence The authority so given may be either absolute or subject to restriction, but must, in any case, be given in writing (or by telegram), and shall be read out by the Secretary for the information of the members and recorded in part I of the Proceedings The document so read by the Secretary shall be held to be complete, and reservations or instructions not contained therein shall not be recognized

9. Casting vote

(*a*) In the event of the votes on any question being equally divided the subject shall be again brought forward during that meeting Should the votes still be equally divided the Chairman or, if he be absent, the Deputy Chairman shall then have a casting vote

10 Ballot vote.

(*a*) In the event of a resolution on any subject having been carried or rejected by less than two thirds of the votes of the members *present at a meeting*, it shall be open to any member with one seconder both present at the meeting, to then move that the question be referred to a general ballot

(*b*) In this case the resolution shall not be considered as finally carried or rejected until it, together with all papers on the subject, have been referred by letter to every member of the Committee, and he has had an opportunity of recording his vote or opinion by letter ballot

(*c*) In alternate years when no meeting is held, all subjects brought forward for discussion shall be submitted to ballot vote Any proposal then approved or rejected by not less than two thirds of the total votes available under sections 5 and 7 shall be considered as finally approved or rejected, and only those proposals for which less than two thirds of the votes available are recorded, either for or against, shall be resubmitted for discussion at the next meeting

(*d*) The Secretary shall forward the papers to each member, and fix a date after which no vote can be received

11 Subjects for discussion

Subjects for discussion in part II shall be brought forward either as (1) a report by the Sub Committee appointed to consider that subject, (2) a reference by any railway officer whether eligible to serve on the Committee or not, (3) a reference by any railway administration or Consulting Engineer.

12 Appointment of Sub-Committees

(*a*) For special subjects, Sub Committees shall be appointed by the General Committee at each meeting to carry on work until the next meeting, and the reports of such Sub Committees shall, as a rule, be submitted annually whether there be a meeting or not

(*b*) Each Sub Committee shall consist of not less than three members Any person whether a member of the General Committee or not, who may be possessed of special qualifications or experience, may be invited by the Sub Committee to assist them

(*c*) One member of each Sub Committee shall be nominated by the Gener Committee to act as Representative, to be generally responsible for the work of t Sub Committee, and to conduct all correspondence which may be necessary

(*d*) The appointment of members to serve on a Sub Committee and the nominatio of the Representative shall as a rule, be confirmed by a show of hands, but should an member of the Committee desire that the votes be formally taken, the voting shall be axles under Rule 7 A member may vote for himself under this rule

(*e*) In the event of absence from India or resignation, of one or more members a Sub-Committee, the remaining members are empowered to appoint new members fill their places, either temporarily or until the next ordinary meeting Should one the members for whom a substitute is thus appointed have been the Representative, Sub Committee shall, *after* filling the vacancy, nominate one of their number to act

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(*b*) Each Sub-Committee shall consist of not less than three members Any person whether a member of the General Committee or not, who may be possessed of special qualifications or experience, may be invited by the Sub Committee to assist them

(*c*) One member of each Sub Committee shall be nominated by the General Committee to act as Representative, to be generally responsible for the work of the Sub Committee, and to conduct all correspondence which may be necessary

(*d*) The appointment of members to serve on a Sub Committee and the nomination of the Representative shall, as a rule, be confirmed by a show of hands, but should any member of the Committee desire that the votes be formally taken, the voting shall be by axles under Rule 7 A member may vote for himself under this rule

(*e*) In the event of absence from India or resignation, of one or more members of a Sub-Committee, the remaining members are empowered to appoint new members to fill their places, either temporarily or until the next ordinary meeting Should one of the members for whom a substitute is thus appointed have been the Representative, the Sub-Committee shall, *after* filling the vacancy, nominate one of their number to act as Representative

(*f*) The Secretary shall at once be informed of any change in the constitution of a Sub Committee made under this rule

13. Duties of Sub-Committees

(*a*) The Committee will from time to time refer particular questions for report to each Sub Committee, but in addition to such questions, each Sub Committee shall as far as possible, report on all questions connected with the subject which it has been appointed to consider

(*b*) Where there has been a preliminary discussion on a subject, and certain leading dimensions or features of design have been laid down by the General Committee, the proposals of the Sub Committee as to details should, as a rule, be based on the resolutions already adopted In special cases, however, where sufficient cause can be shown, the Sub-Committee may recommend such modification as may appear called for

(*c*) Every endeavour should be made by the Sub Committees to secure uniformity and consistency in designs Parts intended to do the same work, or to serve a similar purpose should be of the same design or of similar pattern for both Carriage and Wagon stock, and for both the 5 ft 6 in and metre gauges, and details should, as far as practicable, be made standard and interchangeable

(*d*) The Sub Committees should collect information from each Locomotive and Carriage Superintendent and the Secretary will furnish them with such information in connection with their work as may be available in the office of Director General of Railways

(*e*) Each Sub Committee will furnish the Secretary, not later than 15th September, with a brief abstract of all matter which it proposes to lay before the General Committee, and the Secretary shall have these abstracts printed, and a copy supplied to each member as early as possible

(*f*) The reports of the Sub Committees should be submitted in every respect complete and ready for publication, with all details carefully considered and thoroughly worked out, so as to enable such work to be passed by the General Committee with a minimum of discussion A separate report should be submitted for each separate subject as arranged in the Proceedings

(*g*) The reports of the Sub Committees, together with complete sets of ferrotypes (*see section 25 a*) or tracings ready for ferrotyping may be sent to the Secretary to be printed not later than the 15th October The Sub Committees may if they prefer it, arrange to get their reports printed in this case four complete copies of the report should be sent to the Secretary and one copy to each member of the Committee not later than 15th November

(*h*) No results or conclusions arrived at, or recommendations which may be made by a Sub Committee shall be published except under the authority of the General Committee

14 Subjects for discussion proposed by Individuals

(*a*) Any railway officer, whether eligible to serve on the Committee or not, who wishes to bring forward a subject for discussion, shall submit to the Secretary, *not later* than 15th September, his remarks on the subject in a form convenient for circulation to members *A communication* from an officer not at the head of his department should be sent through his Chief Officer, who may use his own discretion as to its disposal

(*b*) The Secretary will at once forward an abstract of the paper to the Representative of the Sub-Committee concerned, and will send a copy of the complete paper to every member of the Committee, as soon as it can be printed

(*c*) Any officer desiring a full discussion on any subject should send in a paper early in the season, so that it may be circulated to members for consideration as soon as possible, and it is desirable that proposals should, as far as possible, be submitted through the Sub-Committees

(*d*) No proposals made by any individual officer shall be published in any part of the Proceedings, except under the authority of the General Committee

(*e*) *With the approval of the General Committee a brief abstract of the* proposals made by an individual officer, together with any resolution which may be recorded thereon, shall be published in part II of the Proceedings, and the complete paper in part III

(*f*) In the absence of any recorded objection, the approval of the Chairman shall be considered to be equivalent to the approval of the General Committee

15. Subjects for discussion proposed by Railway Administrations or Consulting Engineers.

(*a*) These should be sent as early as possible to the Secretary, who will forward a copy to each member of the Committee It should be remembered that the Committee are not in a position to thoroughly consider a subject without due notice

(*b*) *A brief statement of the proposal made, together with any resolution which may* be recorded thereon, shall be published in part II of the Proceedings, and any lengthy papers connected with the subject in part III

16 Re opening Discussions.

(*a*) The discussion on a subject on which a resolution has been passed shall not be *re-opened for a period of two years, and shall not be submitted to a ballot vote until it* has been discussed at a general meeting, except at the desire of at least two thirds of the members of the Committee, or at the request of the Consulting Engineer to the Government of India For the purposes of this rule, the word 'subject' shall be held to mean such portions of the subject as are covered by the resolution

(*b*) In the case of a resolution passed at an ordinary biennial meeting, the period of two years shall be considered to have expired on the commencement of business at the ordinary biennial meeting next after that at which the resolution was passed

(*c*) Any officer desiring to re open any such question after the end of two years, shall obtain at least two seconders, who shall be members of the Committee, and shall send to the Secretary a notice to that effect, giving reasons for wishing to have the matter brought forward, and any fresh information he may have to lay before the members Such notice should reach the Secretary not later than 15th September, to enable him to have the papers printed and in the hands of the members as early as possible.

(*d*) Paragraphs (*c*) to (*f*) of section 14 of these By laws shall apply to this case.

17. Record of Dissent.

(*a*) Any member wishing to record his dissent *from a resolution adopted by the* Committee shall record briefly what he proposes to substitute in its place, and should, whenever possible, bring forward this proposal in the form of an amendment at the time the resolution is discussed

(*b*) His dissent, and his reasons for it, will be recorded as briefly as possible in the minutes of business transacted He may, either at the meeting, or at any time within two months after it, hand to the Secretary a paper on the subject, giving in full his reasons for dissenting, to be published in part III of the Proceedings

(*c*) In the case of a member being absent from India at the time a resolution is adopted, he should submit a record of his dissent to the Secretary at the earliest possible opportunity In the case of a member who is in India but has been unavoidably absent at a meeting, his dissent should be recorded when the proof of the Proceedings is returned under section 21 A member who has deputed another to vote for him under section 8 is not entitled to record his dissent from such vote

18 Abstract of Business to be transacted

(*a*) The Secretary shall as early as possible after 15th September, supply each member of the Committee with a brief abstract of all matter for discussion of which due notice has been given under sections 13 to 16, and shall, before the meeting, supply each member with a copy of all papers and drawings to be laid before the meeting, except those supplied direct by the Sub Committees under section 13 (*g*)

(*b*) Any proposals submitted for discussion after this has been done shall be considered only if desired by at least two thirds of the members present at the meeting

(*c*) In alternate years when no meeting is held the Secretary will submit all subjects brought forward in accordance with sections 13 to 16, inclusive, to each member not later than 15th December, and each member shall be asked to record his vote or opinion on each subject A statement of the votes and opinions received will be printed by the Secretary, and a copy sent to each member as early as possible, and in any case where the opinion is not unanimous, each member shall be invited to reconsider his vote

19 Discussions at the Meeting

(*a*) In all cases when any subject is considered in Sub Committee at the meeting, a written report signed by at least one member of the Sub Committee, shall be handed to the Secretary, and read out by him to the meeting

(*b*) All resolutions or amendments to be laid before the meeting shall be in writing duly signed, and shall be read out by the Secretary In case an amendment is carried a fresh resolution embodying the amendment shall be written, signed and read out the original resolution being destroyed

20 Check of Proceedings.

(*a*) A copy of every report or proposal brought before the Committee shall be carefully checked by at least one member of the Sub Committee or by the proposer and any errors in it corrected, the corrected copy, duly initialled, being handed to the Secretary before the close of the meeting

(*b*) On the last day of the meeting, after all the business has been transacted, the Secretary will read out the rough draft of the Proceedings This draft will include all subjects which have been disposed of by ballot vote during the preceding year Any amendments or alterations thereto desired by individual members may (with the approval of the Committee) then be made, and the draft as finally adopted will be signed by the Chairman

21 Draft of Proceedings

(*a*) After the meeting the Secretary will, as early as practicable, furnish each member with a proof of parts I and II of the Proceedings, in type, for information and for any remarks that members may desire to make Proposals for important modifications in the draft, or for any change in the wording which would involve alteration in the sense of a resolution, should be brought forward at the meeting before the Proceedings are confirmed, and no such alteration shall be subsequently made unless approved by all the members who were present at the meeting, remarks on the proof copy in type should be limited to suggestions for improvement in minor details of style or arrangement, or corrections to parts of the matter for which the member desiring the alteration is individually responsible

(*b*) The proof thus furnished to each member will be in duplicate One copy to be returned with any remarks or suggestions he may desire *to make, and the other copy to* be kept by him for reference until the final issue is published

(*c*) In sending out the proofs, or proposals for alterations in the draft, the Secretary will note the date up to which remarks or suggestions can be considered, and is authorized to reject any remarks or suggestions which may be received later than the date thus fixed

22 Notes and Correspondence

(*a*) Part III of the Proceedings shall contain in addition to the papers referred to in sections 14 to 17, miscellaneous memoranda and correspondence referred to in the Proceedings, or connected with subjects brought forward for consideration

(*b*) The Committee as a body is not responsible for the opinions expressed in part III of the Proceedings

23 Selected Papers.

Part IV shall contain papers of professional interest or importance, either contributed by the members or other railway officers, or reprinted or compiled from other sources not generally accessible

24 Papers for Publication

(*a*) Papers sent to the Secretary for publication or for discussion by the Committee shall be in every respect ready for the printers, each member should take special care that any paper he may have under preparation meets the following requirements —

(1) To be neatly written in a clear legible hand

(2) The writing to be on one side of the paper only with a clear space of one and a half inches at the top of each page.

(3) The sheets to be the size of a foolscap page (about $13\frac{1}{2}'' \times 8\frac{1}{2}''$) and to be fastened together at their top left hand corners.

(4) Proper names or technical terms to be written distinctly, so that each individual letter may be clearly legible.

(5) Special attention to be paid to tables of figures, diagrams, formulæ, etc., so that they may occupy exactly their intended positions with reference to the text, and that the arrangement intended may in every particular be clearly shown

(*b*) The Secretary is authorized to return for revision any paper sent him for publication which has not been prepared in conformity with the foregoing requirements.

(c) Where practicable members should themselves arrange to have their papers printed locally under their own supervision, and should furnish the Secretary with printed copies for distribution

25 Drawings

(a) Every drawing intended to be laid before the members of the Committee should have on it a date and a reference number or other mark by which it can be subsequently identified, and should be referred to in the printed papers by this number or reference mark

(b) Drawings should be to one of the following sizes —

Half foolscap	$13\frac{1}{2}$ in × $8\frac{1}{2}$ in
Open foolscap . . .	$13\frac{1}{2}$ in × 17 in
Double elephant . . .	27 in × 40 in

and should be sent to the Secretary packed flat between boards or rolled in a tin case Of drawings intended to illustrate a subject for discussion, the number of copies sent should be sufficient to allow one copy for each member of the Committee, with four spare copies in addition The Secretary will if desired undertake the preparation of the spare copies of drawings by the ferrotype process Tracings sent to the Secretary for this purpose should be carefully made with firm opaque *black* lines on good fresh tracing cloth, and should be rolled (not creased or folded) and packed in a tin case

(c) As the plates in part V of the Proceedings are limited to foolscap size ($13\frac{1}{2}$ in × $8\frac{1}{2}$ in) care should be taken to show only such detail as can be reproduced with clearness in a plate of that size It is recommended that, as far as possible, all drawings be made to a suitable scale on either open foolscap size ($13\frac{1}{2}$ in × 17 in) or foolscap size ($13\frac{1}{2}$ in × $8\frac{1}{2}$ in) Drawings of details should, when necessary be on separate sheets

(d) Working drawings to illustrate designs accepted by the Committee will, as a rule, be open foolscap size ($13\frac{1}{2}$ in × 17 in), or, in the case of working drawings of locomotives, double elephant size (27 in × 40 in) one dimension must in all cases be either $13\frac{1}{2}$ inches or 27 inches (*See also Rules for Drawings, Vol III, page 14*)

APPENDIX A

FORM OF APPLICATION FOR SANCTION FOR SPECIAL ESTABLISHMENT

NAME OF MEMBER

NAME OF RAILWAY

NATURE OF WORK TO BE DONE

ESTABLISHMENT REQUIRED

*Cost per mensem*________________

*Number of months*________________

*Total cost*________________

Sanctioned under the provisions of Government of India, Public Works Department, Circular No 168 R S, dated 4th May 1894

Chairman

*Dated*________________

(Spare copies of this form and section 3 of the By laws can be obtained on application from the Secretary)

(*c*) *Where practicable, members should themselves arrange to have their papers* printed locally under their own supervision, and should furnish the Secretary with printed copies for distribution

25 Drawings

(*a*) Every drawing intended to be laid before the members of the Committee should have on it a date and a reference number or other mark by which it can be subsequently identified, and should be referred to in the printed papers by this number or reference mark

(*b*) Drawings should be to one of the following sizes —

Half foolscap . . .	13½ in × 8½ in
Open foolscap	13½ in × 17 in
Double elephant	27 in × 40 in

and should be sent to the Secretary packed flat between boards or rolled in a tin case Of drawings intended to illustrate a subject for discussion, the number of copies sent should be sufficient to allow one copy for each member of the Committee with four spare copies in addition The Secretary will if desired undertake the preparation of the spare copies of drawings by the ferrotype process Tracings sent to the Secretary for this purpose should be carefully made with firm opaque *black* lines on good fresh tracing cloth, and should be rolled (not creased or folded) and packed in a tin case

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(*d*) Working drawings to illustrate designs accepted by the Committee will, as a rule, be *open foolscap size (13½ in × 17 in), or, in the case of working drawings of locomotives,* double elephant size (27 in × 40 in) one dimension must in all cases be either 13½ inches or 27 inches (*See also Rules for Drawings, Vol III, page 14*)

APPENDIX A

FORM OF APPLICATION FOR SANCTION FOR SPECIAL ESTABLISHMENT.

NAME OF MEMBER.

NAME OF RAILWAY.

NATURE OF WORK TO BE DONE.

ESTABLISHMENT REQUIRED.

*Cost per mensem*________________

*Number of months*________________

*Total cost*________________

Sanctioned under the provisions of Government of India, Public Works Department, Circular No. 168 R.S., dated 4th May 1894.

Chairman.

*Dated*________________

(Spare copies of this form and section 3 of the By-laws can be obtained on application from the Secretary)

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

PART II.—BUSINESS TRANSACTED.

CALCUTTA.—DECEMBER 1894.

NOTICE.

It is to be understood that all decisions of the Committee as given in the following pages are subject to the approval or confirmation of the Agent, Boards of Directors, or other authorities for individual Railways, and of the Government of India in all cases.

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

BUSINESS TRANSACTED, 1894.

Locomotives—

Coaching and Goods Stock—

BUSINESS TRANSACTED.

SUBJECT No 1

The most suitable type of engine for each class of work noted below, or for any other set of classes, the Committee may consider better suited for general adoption—

(1) Hea y Incline	*(4) Passenger and Mail*
(2) Goods	*(5) Local Passenger Tank*
(3) Mixed	*(6) Shunting*

The recommendations to be for—(i) 5 ft 6 in gauge, (ii) Metre gauge,—and as far as practicable the engine recommended as the best type for each class for one gauge to be similar in its general characteristics to that recommended for the same class of work on the other gauge

A—APPROVED DESIGNS—5 FT 6 IN GAUGE

Reference

Open foolscap size diagrams of approved designs of engines issued with Secretary's No D 89 of 27th September 1894

Double elephant size drawings of the Bombay and Baroda compound goods engine, of the Eastern Bengal four wheeled coupled bogie engine, and of the Fast Passenger engine, Oudh and Rohilkhand railway pattern, issued with *Secretary's No D 61, dated* 11th April 1894, and No. D 97, dated 12th October 1894

Nothing was brought forward under this subject for the 5 ft. 6 in. gauge.

Locomotives — Subject 1 A — Metre gauge

A.—APPROVED DESIGNS — METRE GAUGE

Reference

Resolution adopted at Madras (*Vol V, page 17*)

Open foolscap size diagrams of the approved designs of engines, issued with Secretary s No D 89 of 27th September 1894

The Sub Committee for the metre gauge submitted the following report the drawings submitted illustrate the report printed on pages 14 to 17 of Vol V —

1 With reference to para 2 of the Resolution adopted at the Madras meeting of the General Committee with respect to the report submitted by the Sub Committee for 1893 this Sub Committee has now the honor to state that the detail drawings for Class F engines, modified referred to in that report have been partly completed and that those not yet ready will it is expected be finished in 1895

2 Particulars of the completed drawings are as follows —

Sheet No	1	General arrangement (*See Plate II Vol V*)
	2	Do do end views (*Do III*)
	3	Boiler (*Plates I and II in this Volume*)
	4	Fire-box crown stays (*Plate III in this Volume*)
	5	Fire hole door (*Plate IV*)
	5 A*	Alternate door (*Plate V*)
	6	Washout door and side expansion angle iron and bracket (*Plate VI in this Volume*)
	11	Ash pan (*Plate VII* ,)
	12	Eccentric straps (*Plate VIII in this Volume*)
	14	Axles (*Plate IX*)
	15	Cranks (*Plate IX*)
	16	Coupling rods (*Plate X*)
	17	Spring hangers (*Plate VIII*)

3 In addition to the drawings specified in last year s report, a few others will, it is found, be necessary in order to fully illustrate the modifications decided upon

4 If on completion of all drawings required in connection with the modified Class F engine the final orders of the Government of India have been received with respect to the General Committee s recommendations, the Sub Committee will then devote its attention to the Class O passenger and mail engine and will submit proposals for such modifications as may appear desirable working up approximately to the increased load if sanctioned

5 There have been some enquiries for a design for a special engine for working on heavy inclines and the Sub Committee proposes to give this matter its consideration also during next year, if the time at its disposal should admit thereof

C E. CRIGHTON

F N GUTERSLOH

C P WHITCOMBE.

NOTE.—Mr Gutersloh objects to certain details in the drawings, particulars will be explained verbally to the General Committee at the Calcutta Meeting

* Plate 5A was added as an alternative arrangement after discussion at the meeting

Locomotives — Subject 1-A. — Metre gauge.

Resolution adopted.

That the drawings presented by the Sub-Committee with certain modifications decided on at this meeting be published in accordance with the recommendations made in the report printed at pages 14 to 17 of Volume V.

(Sheets 1 and 2 have already been published as Plates II and III in Volume V, the remainder are published as Plates I to X in this Volume.)

NOTE.—Mr Gütersloh records his objection to the link stays shown in Figure B Plate III as he considers that in practice it would be difficult to fit them, and to put the pins in. Also the crown of fire box and outer shell must be perfectly parallel both ways, or the links must be made of special lengths to suit any difference.

2. With reference to paragraph 4 of this report, and paragraph 1 of the resolution adopted at Madras, the general question of weights of engines has been taken up by the Consulting Engineer to the Government of India for State Railways, and a reference to the Committee has been made by him which is recorded under Subject 3 O *(page 34 in this Volume)*.

3. With reference to paragraph 3 of the Madras resolution, it was pointed out by the Secretary that the Government of India would not at present alter the existing limits given in Standard Dimensions, but that no objection would be raised in cases where the necessary certificate is obtained that the permanent-way and bridges are of sufficient strength to carry the increased load.

SUBJECT No. 2.

The design of parts of Engines and Tenders with the view generally to securing greater uniformity in practice on different Railways, and specially to the gradual introduction and extension of a system of standard details and fittings which shall be alike and interchangeable on all Railways of the same guage, and also where practicable on Railways of both gauges.

Reference.

Resolution adopted at Madras (*Vol. V, page 23*)

Samples of mountings were exhibited by the members of the 5 ft 6 in. gauge, but no report was presented by the Sub-Committee.

Mr Phipps exhibited a restarting combination injector by Messrs Holden and Brooke which had been introduced upon the Madras and Bombay, Baroda and Central India Railways with very satisfactory results

Messrs. Heatly Gresham & Co of Calcutta repeated the offer made by them at Madras to supply for trial, free of cost, any articles for which they are the agents in India.

Resolution adopted.

1. The attention of the Sub-Committee for the 5 ft. 6 in. gauge is invited to the resolution adopted at Madras and printed in Volume V, page 23. It was then decided that the 5 ft. 6 in and metre gauge Sub-Committees should confer together and report to what extent it is desirable to adopt fittings which shall be interchangeable between the two gauges

2. That in addition to this the Sub-Committee for the 5 ft. 6 in gauge report what fittings it considers should be adopted as standards for that gauge only.

SUBJECT No 3

Any subject connected with the design or working of Locomotive Engines which may, with the approval of the Committee, be brought forward for consideration or discussion, in addition to those covered by Subjects Nos 1 and 2

A *Compound engines*
B *Firebars for locomotives*
C *Softening and purifying water*
D *Securing cross head pins*
E *Fuel equivalents*
F *The size of fire boxes*
G *Cracked tube plates*
H. *Flexible stays*
I *Boiler covering and coating*
J *Smoke box tube plates*
K *Speed indicators*
L *Apparatus for picking up "Line Clear"*
M *Minimum dimensions for journals, etc*
N *Minimum dimensions for tyres*
O *Axle load and weight of engines*
P *Metallic packing*
Q *Classification of engines*
R *Designations of engines*

E—FUEL EQUIVALENTS

Reference

Resolution adopted at Madras (*Vol I page 24*)

Note by Mr C E Crighton Locomotive Superintendent South Indian Railway (*Vol V, pages 84—92*)

Note by Mr C F Cardew, Locomotive Superintendent Burma Railway shewing actual consumption and cost of working with different fuels on Toungoo Mandalay line (*page 128 in this Volume*)

Further note by Mr C E Phipps Locomotive Superintendent Madras Railway (*page 130 in this Volume*)

Attention was drawn to the desirability of ascertaining the calorimetric value of fuels by laboratory experiments, or at least of testing the proportion of ash by complete combustion of a weighed quantity and then weighing the ash (*See Part III, page 134*)

Locomotives — Subject 3 F — Both gauges.

F—THE SIZE OF FIRE-BOXES FOR BURNING INFERIOR COAL

Reference

Resolution adopted at Madras (*Vol. V, page 25*)

Note by Mr C E. Cardew (*page 128 in this Volume*)

Resolution adopted.

1 The resolution adopted at Madras, stating that ' a fire box of medium size has been found to burn satisfactorily both English and Indian coal, with a suitable modification of the air spaces and blast," was passed on the assumption that the fuel was of fairly good quality, whereas the question at issue is rather whether it is desirable to design fire boxes to burn the inferior qualities of coal which are now becoming common and which it may be advisable in the future to use more generally for the sake of economy

2 The Committee considers that fire boxes should be designed to suit the particular coal used, their size being increased where it is probable that inferior descriptions are likely to be used in the future When the evaporative power of the fuel, and the duty to be performed by the engine in a given time are known, the area of fire grate required can be arrived at

3. The information at present before the members is not sufficient to enable them to pronounce a definite opinion, and individual members are again invited to submit statements of the results of their experience, especially in burning inferior Indian coal in the engines with large fire boxes which are now being sent out to this country

Locomotives — Subjects 3 G, H and N —Both gauges.

G —CRACKED TUBE-PLATES

Mr E S Luard, Assistant Locomotive Superintendent, Bombay, Baroda and Central India Railway, submitted a note which is printed at page 136 in this volume

H —FLEXIBLE STAYS

Mr C E Cardew, Locomotive Superintendent, Burma Railway, submitted a note on Wehrenfennig s Flexible Stays which is printed at page 138 in this volume *See also Vol II, pages 63 and 65*

N —MINIMUM DIMENSIONS AND FASTENINGS FOR LOCOMOTIVE TYRES

Mr C E Phipps submitted a paper on the above subject, pointing out that he had found considerable difficulty from the tyres of engines and tenders to which brakes were applied in descending long in lines working loose The paper is printed in full at page 140 of this volume, and previous notes on the subject of tyre fastenings are given in Vol III page 91, and Vol IV, page 60

Resolution adopted.

That the question of minimum thickness for the tyres of engines and tenders be referred to the Sub Committees for Locomotives for consideration

O.—WEIGHT OF LOCOMOTIVES AND ROLLING STOCK

Mr J R Bell, Consulting Engineer to the Government of India for State Railways, submitted a paper on this subject with reference to paragraphs 1 and 3 of the resolution adopted at Madras, printed on page 17 of Volume V, and other similar resolutions, in which he advocates the following limits —

Maximum load in tons on any pair of wheels $= \frac{10\,D}{3}$, (1)

where D is the diameter in feet of the wheel

Maximum in the case of coaching vehicles, including all braked stock, all engine tenders, and all mixed engines $= \frac{10\,D}{3.5}$. (1a)

Maximum for express engines $= \frac{10\,D}{4}$. (1b)

A mixed engine is defined as having two coupled driving axles and wheels not less than 2¼ or more than 2¾ strokes in diameter, an express engine has driving wheels larger than 2¾ strokes diameter

The above maxima must not exceed $\frac{10\,G}{3}$ where G is the gauge in feet.

Wheel base for vehicles should not be less than half length over buffers, subject to certain minimum limits both for vehicles and engines

The minimum distance apart in feet for engine wheels should be—

For goods engines ..	$\frac{2\,L}{5}$	(2)
For mixed engines	$\frac{2\,L}{4}$	(2a)
For express engines .	$\frac{2\,L}{3.5}$	(2b)

Where L is the load on a pair of wheels in tons and the maximum load [illegible] permitted in the leading wheels of coupled engines

The maximum load permissible on any pair of wheels must also be limited according [illegible] the equation

$$W = \frac{20\,L}{3} \qquad (3)$$

Where W is the weight of rail in Pounds per yard and L is the maximum [illegible] permissible on a pair of wheels

For mixed engines the limit would be	$W = \frac{20\,L}{3.5}$	(3a)
For express engines	$W = \frac{20\,L}{4}$ ...	[illegible]

The full text of this note is printed at page 142 in this volume

Resolution adopted

1 That the questions submitted by the Consulting Engineer for [illegible]ation of the Committee are so important that it is desirable that [illegible] should have ample time to consider the matter, for not only are the [illegible] advanced somewhat pronounced, but they are supported by argum[illegible] monly accepted in the form put forward by him

O —WEIGHT OF LOCOMOTIVES AND ROLLING STOCK

Mr J R Bell, Consulting Engineer to the Government of India for State Railways, submitted a paper on this subject with reference to paragraphs 1 and 3 of the resolution adopted at Madras, printed on page 17 of Volume V, and other similar resolutions, in which he advocates the following limits —

Maximum load in tons on any pair of wheels $= \frac{10\,D}{3}$, (1)

where D is the diameter in feet of the wheel

Maximum in the case of coaching vehicles, including all braked stock, all engine tenders, and all mixed engines $= \frac{10\,D}{3{\cdot}5}$ (1*a*)

Maximum for express engines $= \frac{10\,D}{4}$. (1*b*)

A mixed engine is defined as having two coupled driving axles and wheels not less than 2¼ or more than 2¾ strokes in diameter, an express engine has driving wheels larger than 2¾ strokes diameter

The above maxima must not exceed $\frac{10\,G}{3}$ where G is the gauge in feet.

Wheel base for vehicles should not be less than half length over buffers, subject to certain minimum limits both for vehicles and engines

The minimum distance apart in feet for engine wheels should be—

For goods engines ... $\frac{2\,L}{5}$. (2)

For mixed engines .. ... $\frac{2\,L}{4}$ (2*a*)

For express engines .. $\frac{2\,L}{3{\cdot}5}$ (2*b*)

Whe e L is the load on a pair of wheels in tons, and the maximum load should not be permitted in the leading wheels of co ipled engines.

The maximum load permissible on any pair of wheels must also be limited according to the equation

$$W = \frac{20\,L}{3} \qquad (3)$$

Where W is the weight of rail in Pounds per yard and L is the maximum load in tons permissible on a pair of wheels

For mixed engines the limit would be $W = \frac{20\,L}{3{\cdot}5}$ (3*a*)

For express engines $W = \frac{20\,L}{4}$ ... (3*b*)

The full text of this note is printed at page 142 in this volume.

Resolution adopted

1. That the questions submitted by the Consulting Engineer for the consideration of the Committee are so important that it is desirable that each member should have ample time to consider the matter, for not only are the conclusions advanced somewhat pronounced, but they are supported by arguments not commonly accepted in the form put forward by him

Locomotives — Subject 3 Q. — Both gauges.

_______________ Railway.

Appendices to analysis of working half-year ended _______________

APPENDIX I.

Working of Locomotives.

Reference to Revenue Account: Table and main head	Reference to Revenue Account: Sub-head	DETAILS.	CLASS.* A 18 / 4×78	B 18 / 4×72	C 18 / 6×60	D 17 / 6×60	E. 16 / 4×66	F. 15 / 1×78	Miscellaneous and obsolete	TOTAL
		Locomotive. Tractive force per lb of pressure in cylinder† ...	.08	108	129 6	115 6	85 3	72 2	.	
		Locomotive. Gross weight of engine . . Tons	46	42 46 A Boiler	44 38	34	33	29	39 20, 27 & 26	
		1. Number of locomotives erected and made over to Locomotive Department								
		2 Average number of locomotives constantly under repairs and renewals								
		3 Number of locomotives laid by as spare								
		4 Number of locomotives lent or hired out to other lines								
		5 Average number of locomotives 1 — (3+4)								

6. Total mileage of locomotives (5) .. ...
7. Average miles run by a locomotive 6 ÷ 5 per diem ...

Weight of fuel consumed per engine mile‡ .

8 ... In coal burning engines ... lbs.
9 ... ... „ wood „ „ ... lbs
10 Average consumption of fuel per engine mile§ ... lbs

	Passenger trains	Goods trains.	Mixed trains.
11. Average gross weight of trains hauled ... Tons			
12 Average speed between stations ... miles per hour			
13 Average through speed miles per hour			

* The letter in the numerator is the code letter of own or railway the figure is the diameter of cylinder in inches; the first figure of denominator shows the number of wheels coupled, and the second their diameter in inches.

† (Diameter of cylinder)² × stroke ÷ diameter of wheels.

‡ Actual consumption.

§ In terms of standard fuel as laid down in Government India orders.

Locomotives — Subject 3-Q. — Both gauges

FORM No. XII.

Statement of rolling-stock for half-year ended ______

Description.				1	2	3	4	5	6	7	8	9	10	11
										Repairs and Renewals.				
Tender or Tank	Class.	Tractive force per lb of pressure in cylinders	Gross weight of engine tons	Total stock authorised	Total stock constructed against authorisation up to the last day of the previous half year	Addition to stock during the half year	Reduction of stock.	Total stock on the list at end of the half year	Actual stock in running order on the last day of the half-year	Number of engines repaired during the half-year	Number of engines renewed during the half year	Number of engines undergoing or awaiting repairs on the last day of the half year	Number of engines undergoing or awaiting renewals on the last day of the half year	Average number undergoing repairs and renewals at any one time.
Tender	A 18/[illegible]	108	46											
Do. .	B 18/[illegible]	108	42 / 46 A boiler											
Do. ..	C 18/[illegible]	129.6	44 / 38											
Do. .	D 17/[illegible]	115.6	34											
Do. .	E 16/[illegible]	85.3	33											
Do.	F 15/[illegible]	72.2	29											
Tank .	Miscellaneous and obsolete	...	39, 29, 27, 26											
		Total Locomotives ..												

Coaching Stock — Subject 4 A. — 5 ft 6 in gauge

SUBJECT No 4

The most suitable type, general arrangement and leading dimensions of carriage body for each of the purposes noted below, or for any other set of classes the Committee may consider better suited for general adoption It is intended that the list should embrace every kind of coaching vehicle in ordinary use common to most Indian railways, omitting such vehicles as must be specially designed to meet special requirements —

Inspection Carriage	*Third class—(Military type)*
First Class—(Ordinary)	*Post Office*
Composite—1st and 2nd	*Horse box*
Second Class—(Ordinary)	*Carriage Truck*
Intermediate	*Luggage or Road Van*
Third Class—(Ordinary)	*Brake van—(Ordinary)*

The recommendations to be for—(i) 5 feet 6 inch gauge, (ii) metre gauge, and as far as practicable the carriage recommended as the best type for each class for one gauge to be similar in its general characteristics to that recommended for the same class of work on the other gauge —

A —General arrangement of body
B —Cross section
C —Fittings

A—GENERAL ARRANGEMENT OF BODY — 5 FT 6 IN GAUGE

Reference

Resolution adopted at Madras *(Volume V, page 28)*

The Sub Committee for the 5 feet 6 inch gauge submitted the following reports —

1 Our work has been principally confined to reproducing the drawings submitted to the Lahore Meeting on 27 feet underframes referred back to us under Resolution A 1 of the Madras Meeting (*Volume V, page 28*) and in accordance with this resolution we submit the following drawings—

No. 1	Standard design for body for I II or composite carriage ...	27 ft 2 in. long	*(Plate XI)*
„ 2	Standard design for III class body	... 27 ft. 6 in. long	*(Plate XII)*
„ 3	Standard design for body of luggage-van ...	... 27 ft. 2 in. long	*(Plate XIII)*
„ 4	Standard design for body of brake van ...	... 27 ft 2 in. long	*(Plate XIV)*

SUBJECT No 4

The most suitable type, general arrangement and leading dimensions of carriage body for each of the purposes noted below, or for any other set of classes the Committee may consider better suited for general adoption It is intended that the list should embrace every kind of coaching vehicle in ordinary use common to most Indian railways, omitting such vehicles as must be specially designed to meet special requirements —

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First Class—(Ordinary)	*Post Office*
Composite—1st and 2nd	*Horse box*
Second Class—(Ordinary)	*Carriage Truck*
Intermediate	*Luggage or Road Van*
Third Class—(Ordinary)	*Brake van—(Ordinary)*

The recommendations to be for—(i) 5 feet 6 inch gauge (ii) metre gauge, and as far as practicable the carriage recommended as the best type for each class for one gauge to be similar in its general characteristics to that recommended for the same class of work on the other gauge —

A —General arrangement of body
B.—Cross section
C —Fittings

A —GENERAL ARRANGEMENT OF BODY — 5 FT 6 IN GAUGE

Reference

Resolution adopted at Madras *(Volume V, page 28)*

The Sub Committee for the 5 feet 6 inch gauge submitted the following reports —

1 Our work has been principally confined to reproducing the drawings submitted to the Lahore Meeting on 27 feet underframes referred back to us under Resolution A 1 of the Madras Meeting (*Volume V page 25*) and in accordance with this resolution we submit the following drawings—

No. 1 Standard design for body for I, II or composite carriage ...	27 ft 2 in. long	*(Plate XI)*
„ 2 Standard design for III class body	27 ft. 6 in. long	*(Plate XII)*
„ 3 Standard design for body of luggage-van ...	27 ft. 2 in. long	*(Plate XIII)*
„ 4 Standard design for body of brake van	27 ft. 2 in. long	*(Plate XIV)*

Coaching Stock — Subject 4 A — 5 ft 6 in gauge

2 It is unnecessary for us to remark on these drawings, the general designs having been fully described and agreed to at previous meetings, and they are now submitted for final approval of the General Committee to be published as standards

---

Mr C E Phipps member of the Sub-Committee, dissents from certain of the details of the drawings submitted and suggests the following alterations —

Standard 27′ 2″ coach body for I, II or composite class

Standard 27′ 6,″ coach body for III class

3 *I have signed the two tracings, though I think, as a matter of detail I should prefer* in the I class body that the doors should be made to open outwards instead of inwards, and further that the Madras railway standard sliding seats should be used or at any rate permissible, in the I class compartments and also that in both forms of body the outer paneling should run through to the bottom of the body without any cross battens

4. I am aware that the object of making the carriage doors open inwards is to secure greater safety, but to carry out this principle all III class carriage doors should also be made to open inwards As at present arranged at any rate the doors of I class carriages, when open, take up a large portion of the opening and further the sunshades generally, if not always, project so far beyond the door when open as to cause imminent danger to the head of the person getting into the carriage

5 With regard to the Madras railway sliding chair seats these are very generally approved by the travelling public of Southern India, affording as they do an opportunity of varying a recumbent position during a long journey, to a sitting one in a very fairly comfortable and convertible chair The cross battens of the outer paneling are I have found, a continual source of trouble, as they offer a lodgment for water and it is impossible to prevent consequent rust and destruction of the iron panels There is no difficulty in making plates the full length of the panel and doing away with all cross battens and further securing them at the bottom of the lower side without a batten and in such a way that the water can drop clear

6 With regard to the body of the luggage van I should prefer as a matter of detail, that the outer paneling should run through to the bottom of the body without any cross battens

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To this the two other members of the Sub Committee replied —

7 With regard to the remarks by Mr Phipps on *doors opening outwards* this was fully discussed at the Lahore and other meetings, and it was decided that inside doors were necessary, because, first, with a 9 feet body the door can be only 2 feet with safety, giving a clear opening of about 1 foot 10 inches not sufficient for the luggage or convenience of 1st and 2nd class passengers Any door outside this dimension would not be safe and against Government rules,* besides at stations with only 6 feet between tracks it could not be opened with a train on the next line With the approved 3rd class lateral compartments doors cannot be made to open inside

8 *Sliding chair seats* are no doubt in some respects a convenience in converting a seat into a chair. In Bengal and the Punjab they were tried years ago and abandoned One great disadvantage is that the space under seat cannot be used for luggage another, that

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* The only Government limit at present is 14 feet, but this will probably be reconsidered.—F. [illegible]

Coaching Stock — Subject 4-A. — 5 ft. 6 in gauge

when used as a bed it cannot be widened by sliding out, a great convenience with the present seat to invalids and stout persons. If the fixed seat is made wide enough for a bed, it is too wide for a seat, and when used as a bed, ridges of the separate cushions make it uncomfortable unless a mattress is used.

9 *The outside panelling* is not before us; all that we think required is a general standard drawing for a carriage, the details, such as outside panels whether run down to the bottom or not, or whether of wood or iron, can be left to each railway

10. At the request of Mr. Phipps a design of the *brake-van in use on the Madras railway with wooden frame* is also submitted for consideration.

R. PEARCE.

C. T. SANDIFORD.

C. E. PHIPPS

Resolution adopted

1. That the designs submitted by the 5 feet 6 inch gauge Sub-Committee for I, II and composite class on 27 feet frames be accepted as "Approved Designs" as regards the general arrangement (*see plate XI in this Volume*). That details, such as the style of seat, arrangement of paneling, etc, be left open. The members of the Committee representing the 5 feet 6 inch gauge are of opinion that for general use the sliding seats shown in the plate are preferable to chair seats which open out to form a couch, but there is no objection to any lines using the latter if they find them suitable to their traffic

NOTE.—Mr Wimmell records his dissent, as he considers that a length of body of 25 feet 6 inches is ample for these classes and that this can be built on frames 24 feet long

This subject was very fully discussed at the Lahore Meeting, at which Mr Wimmell was present, and it was then recorded *(Volume IV, page 19)* that the Committee unanimously resolved that a *27* feet underframe would meet all requirements for I, II, composite and III class carriages as well as coaching brake-vans

2. That the designs for III class, Luggage-van and brake-van be accepted as "Approved Designs" (*see plates XII to XIV in this Volume*).

3 With regard to the Madras brake-van, on wooden frame, the outline of the roof does not correspond with the standard section adopted for coaching stock (*see also paragraph 3 of the Resolution adopted at Lahore, volume IV, page 19*), but with this exception the Committee considers it a suitable design for railways in a climate not liable to extremes of damp and dryness.

4. That the attention of the Sub-Committee be invited to paragraph 3 of the resolution adopted at Madras, and that they consider designs for bogie stock and report thereon to the General Committee.

Coaching Stock — Subject 4 A — Metre gauge.

A —GENERAL ARRANGEMENT OF BODY — METRE GAUGE

The metre gauge Sub Committee submitted the following report —

1 *Standard type drawings for 1st, 2nd and 3rd class* —Following up the resolution adopted last year at the Madras Meeting on the Sub Committee s report (*see volume V, page 29 or Reprint of Business page 90*) the Sub Committee now presents a drawing No $\frac{14}{6}$ showing general arrangements for coaches providing 1st 2nd and 3rd class accommodation These general arrangements are ones in extensive use and are considered suitable for ordinary practice where only minimum accommodation is to be provided in each class It will be observed that the 1st and 2nd classes are combined in one composite carriage These type drawings should be taken as in supersession of those published in volume II plates 21, 22 27, and 29 The Sub Committee would have liked to have revised the drawings of other classes of vehicles shown in plates 21 to 30 inclusive, but found the time at its disposal insufficient for doing so Next year it is hoped that this may be done, together with the addition of certain other useful classes of vehicle on the standard underframes agreed upon last year Meanwhile, however there will be no difficulty in adapting any of the designs in the above quoted plates to suit the standard underframes when required It will be recollected that those plates of type drawings were adopted by the Committee merely as 'Approved Designs' (*see volume III, page 35 or Reprint of Business, page 88*)

(Para 2 of this report is given on next page)

NEGAPATAM

26th October 1894

C E CARDEW
C E CRIGHTON
C P WHITCOMBE

Resolution adopted

That the recommendations of the Sub Committee be accepted and the drawings published as Approved Designs" (*see plates XV to XVIII in this Volume*)

B —CROSS SECTION — BOTH GAUGES.

Maximum width of vehicles and width of 3rd class seats

Reference

Resolutions adopted at Madras (*Volume V pages 30 and 33*)

The Sub Committee for the metre gauge pointed out that this question has not yet been settled It has therefore shown the cross seated 3rd class coach with the standard cross section adopted at Madras for coaching stock (*see volume V, plate XVI*)

Resolution adopted

With reference to the resolution adopted at Madras (*Volume V, page 30*) the Committee has ascertained that existing wagons, measuring 10 feet 6 inches over all in the body, or 6 inches more than the Committee then recommended are permitted to run without restriction over every 5 feet 6 inch gauge line in India, and that the only inconvenience which has arisen from their use is due to the difficulty of seeing the side lights of the brake van from the engine

Mr Pearce who was not present at the Madras meeting pointed out that he considered it objectionable to allow side-lights to project beyond the 10 feet 6 inch limit on the East Indian or Great Indian Peninsula Railways where the tracks are only 12 feet centres as they might be struck by the open doors of a passenger vehicle on the other line

It was also pointed out that the representatives of the Great Indian Peninsula and East Indian railways had at Bombay (*Volume II page 29*) recommended the Committee to consider a passenger vehicle with a width over body of 10 feet instead of 9 feet

Coaching Stock — Subject 4-B. — Both gauges

Height of metre gauge vehicles at sides

Reference

Resolution adopted at Madras (*Volume V, page 31*)

READ—*Government of India's* P W D Circular No 10 Railway, *dated* 18th *October* 1894

Standard dimensions to be observed on metre gauge railways in India.

The following alterations should be made to the revised schedule of standard dimensions *to be observed on all metre gauge railways in India as prescribed in above circular* —

Item 76 —Maximum height from rail level for unloaded vehicle at sides

For "10 ft 0 in" *Substitute* "10 ft 2 in"

Item 87 —Maximum height above rail level for floor of any vehicle unloaded (with 2 ft 4 in wheels)

For "3 ft, 0 in" *substitute* "3 ft 1 in"

C —CARRIAGE FITTINGS — BOTH GAUGES

Reference

Resolution adopted at Madras (*Volume V, page 33*)

The Sub Committee for the 5 feet 6 inch gauge presented the following report —

We feel that any drawing we can prepare will be merely a reproduction of information already submitted and are of opinion that the only satisfactory plan will be to select details from actual samples produced at the meeting There is also the conviction that it is difficult in many cases to decide that one fitting is really better than another it is so much a question of taste, and as no further information has been sent in by members, the samples with others will be resubmitted

Mr R Pearce, representative of the Sub Committee, also presented the following report —

Very little has been done in coming to any conclusion on this subject and it has been referred from meeting to meeting As mentioned in the Sub Committee s report, they can only resubmit those fittings which have been before the members at other meetings with a few additions

It is no doubt difficult to decide that one fitting is better than another, but I think some progress might be made, if at each meeting certain patterns were selected and recorded as ' Approved Fittings and probably in this way, in time certain standards would be arrived at

I would remark on the following fittings now put forward —

Vulcan Cloth —The pattern bed and seat shown at the meeting have been trimmed with this cloth The East Indian railway have had for some months a through carriage, one compartment trimmed with this cloth and the other with buffalo hide, at present with no difference in appearance or wearing qualities

The cost of trimming a carriage (two compartments) with vulcan cloth (for cloth only) is Rs 248 against buffalo hide Rs 416 or a difference in favour of the vulcan per carriage of Rs 168

Door handles —A carriage will be shown to the members, half the doors on one side being fitted with Wethered s locks and half with Defries' which have been running and in constant working since November 1892

It will be for the meeting to form an opinion on their relative merits

On the East Indian railway *the Traffic Department greatly prefer the Defries lock, and until some other lock is produced will continue to use it An improved Defries'* lock will be shown having been made practically " dust proof, " and this lock has now been working for some time with very satisfactory results, it does not clog with dirt the same as Wethered's or old pattern Defries, and the slot in bottom allows the dust to get away.

Coaching Stock — Subject 4 C — Both gauges

Metal glass frame and cork bedding —This is entirely new, and I saw it for the first time when in England last year The metal frame is coming largely into use in England On the East Indian railway the breakage of window glasses is very great, and taking the frame to pieces to remove the glass means as a rule replacing a frame and the cost of this is considerable It is claimed that with the metal securing frame the window frame is left intact and the life prolonged indefinitely, the cost of replacing a glass nominal, being done in a few minutes by any ordinary workman

I have tested the working of these frames and deem them of sufficient merit to bring before the Committee, with their use I feel sure our working expenses would benefit considerably One objection perhaps is that up country the frame might be taken out and stolen, but this could easily be overcome by securing the frame in one or two places

Anti friction door hinge — A sample of this hinge is shown and it appears to be of sufficient merit to bring before the Committee It is I think a great improvement on the present hinge giving as it does so much more bearing surface, and for this reason three hinges per door can be used instead of our present practice of four hinges One important point about the hinge is being able to take the door off for repairs, without taking off the standing pillar portion of hinge, this will save pillars considerably

Wash hand stand with tip up basin soap dishes, etc —An improved pattern of this is shown The old arrangement of levers and rods for opening and closing has been done away with and quadrants substituted Boxes for brushes etc have been added and stand for glasses Instead of opening and shutting by raising the lid this is done by lowering or lifting the front of box without any danger

Spring window blind —A simple arrangement and what I think a good one for working and lowering the blind to various heights is shown This is a plan worked out by our Carriage Foreman Mr Le Feuvre

Rubber rests and cushions for window frames —Since I addressed you on this I have had considerable experience of their satisfactory working Patterns will be shown

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The metre gauge Sub Committee submitted drawings of improved 'Wethered's patent door locks, which have been published in Volume V, plates XXIX and XXX, and Mr C E Cardew exhibited a sample of this improved lock

Mr J J Adler exhibited a self closing lock of his invention and an automatic door catch, the invention of Mr Stephens

A sample of a self closing lock invented by Mr Luard was also exhibited this claims to be perfectly dust proof but at present has certain defects which, it was stated Mr Luard intended to get rid of

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Coaching Stock — Subject 4-C. — Both gauges.

Resolution adopted.

1 The fittings exhibited by Mr. Pearce, and referred to in his report, are recommended to the notice of members as likely to be found suitable for general use; but in the absence of further experience, it is not considered advisable to recommend them as "Approved Designs" or to publish drawings.

2. The Committee considers that the glass frame would be more likely to give satisfaction if made of material other than brass, which is most likely to be stolen. Probably English manufacturers are not aware of this objection.

3. The India-rubber cushions and stops which have been largely tried, are recommended as "Approved Designs," and drawings are published in plate XIX in this volume.

Theft of fittings of brass or cloth.

This question was also discussed; it was pointed out that whenever iron was suitable, its use greatly decreased the chance of theft; also the use of rivets in place of screws for brass fittings was recommended wherever practicable. In the case of cloth articles, weaving in a monogram at close intervals reduced, but did not entirely prevent theft.

SUBJECT No. 5

The most suitable type, general arrangement and leading dimensions of wagon body for each of the purposes noted below, or for any other set of classes the Committee may consider better suited for general adoption It is intended that the list should embrace every kind of goods vehicle in ordinary use common to most Indian railways, omitting such vehicles as must be specially designed to meet special requirements —

Covered Goods (Ordinary)	*Open Goods (Military type)*
Covered Goods (Military type)	*Timber truck*
Open Goods (Ordinary)	*Powder van*

Brake van (Ordinary).

The recommendations to be for—(i) 5 feet 6 inch gauge, (ii) metre gauge, and as far as practicable the wagon recommended as the best type for each class for one gauge should be similar in its general characteristics to that recommended for the same class of work on the other gauge

A —General arrangement of body
B.—Cross section
C —Fittings

A —GENERAL ARRANGEMENT OF BODY — 5 FT 6 IN GAUGE

The Sub Committee for the 5 feet 6 inch gauge submitted the following report —

1 We submit the following drawing in accordance with the resolution passed at Lahore (*Volume IV, page 22*) —

18 ft 0 in. iron covered good wagon with sheet iron roof without military fittings *

2 In regard to this, we have to remark that the length of this wagon (and also covered goods illustrated in plate 31 of Volume II and plates III to VI in Volume IV) was originally designed with 18 feet body, and 22 feet 2 inches over buffers, which may be reduced to 21 feet by shortening buffers, for a given tonnage of 24 tons gross, coming well within the sanctioned limit of 1 2 tons per foot run over buffers but this having been reduced to 1 06 ton per foot will necessitate the wagon being increased to 22 feet 8 inches over buffers We believe that one railway is in the unenviable position of having adopted the shortened buffer with an 18 feet body, or 21 feet over all, equal at 1 06 tons per foot to a gross of

* This drawing has already been published in plate IV, Volume IV

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Brake van (Ordinary).

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* This drawing has already been published in plate IV, Volume IV

Goods Stock — Subject 5-A. — 5 ft 6 in gauge

22 26 tons, or a ton and a quarter less in carrying power than they would have been with their old 18 feet wagon with 4 feet 2 inches buffers, 22 feet 2 inches over all, or 23 48 tons gross.

3 As designers of rolling stock, our object is to obtain the maximum amount of carrying power with a minimum of tare weight, we cannot do this in the direction of width on account of running dimensions, and we believed we had attained our object in the 18 feet covered goods wagon with shortened buffers or 21 feet over all, giving a tare weight of wagon of 7 tons with a carrying capacity of 17 tons or gross 24 tons, ratio of tare to load 1 to 2 43 not before reached on any broad gauge vehicle we know of, either with bogie or four wheeled vehicles and only equalled with all their advantages of width compared with gauge by the metre gauge wagons

4 In order to come within the present ruling of 1 06 ton per foot we require to increase the length of wagon, or, in other words, to add from ½ to ¾ ton to the tare, not only reducing the carrying or paying capacity of the wagon by this amount, but necessitating the haulage and loss of freight on the same quantity for ever

5 In putting forward these remarks, we do not desire to question the advisability of reducing the load per foot run from 1 2 to 1 06 ton, but the present wagon is, with 24 tons gross,—

18 ft. + 4 16 ft. = 22 16 ft = 1 083 ton per foot,

or with shortened buffers—

18 ft + 3 ft = 21 ft. = 1 142 ton per foot,

and it is we think worthy of consideration whether the limit of 1 06 ton cannot safely be raised to 1 142 ton, or, if not, whether the bridges should not be strengthened

6 We submit to the General Committee for consideration the following tracings —

Nos 125 to 131 Con of 24 ft Cylindrical Oil Tank Van with details for conveyance of mineral oil in bulk

7 *Height of sides or open goods wagons*—The Secretary has referred to us the question as to height of sides to suit the traffic on different lines The height shown on plate VII of Volume IV is 2 feet 7 inches, and this appears to be a good height for general traffic, and coal up to 22 tons gross, for 24 tons gross, we think the sides should be raised to 2 feet 9 inches Raising the ends by portable flap doors, a design for which is submitted under subject 5 C (*page 52*), adds considerably to the carrying capacity of this wagon over those with the old short end doors

R. PEARCE.

C T SANDIFORD

C. E PHIPPS

With reference to paragraph 2 of the report, it was pointed out by the Secretary, that the limit of weight per foot run over buffers had not been reduced by the Government of India below 1 2 tons, but that under paragraph 3 of Government of India, Public Works Department, Circular No 5 Railways of 1892, on certain railways, including the East Indian and North Western, Government Inspectors had declined to grant the necessary certificate that this load might be adopted, the limit of 1 06 tons being that fixed on the East Indian on account of the weakness of certain bridges of comparatively large span

Goods Stock — Subject 5-A. — 5 ft 6 in. gauge.

It was further pointed out that, generally speaking, the older bridges are strong enough to carry a load of wagons weighing 1 15 ton per foot run, but are not strong enough to carry this when it follows directly behind a heavy engine and tender, which weigh in many cases about 2 tons per foot of distance from the leading wheels to the rear buffers of tender That possibly in most cases placing an empty vehicle between the tender and first loaded vehicle on all goods trains running over the length in which such weak bridges are situated would get over the difficulty

Mr Sandiford, the Locomotive Superintendent of the North Western railway, also informed the meeting that on that railway it was probable that within a year or two all the bridges would have been strengthened or reconstructed to admit of the full load being carried

Resolution adopted.

1 **Weight per foot run of vehicles** —That the question raised in paragraphs 2 to 5 of the report is a very important one and appears to affect some lines on the metre gauge, as well as on the 5 feet 6 inch gauge That every Locomotive and Carriage and Wagon Superintendent should enquire from the Engineering Department of his railway what particular bridges, if any, are too weak to allow a train load of 1 2 tons per foot on 5 feet 6 inch gauge, or of 0 8 ton per foot on metre gauge to be worked to when hauled by existing engines, and whether the remedy suggested by the Secretary would meet the difficulty

2 That the question of the economy of adopting the remedy suggested be also fully considered by the sub committees bearing in mind that the light vehicle would be required in *all* goods or mixed trains whether the following vehicles were loaded to the full load of 1 2 tons and 0 8 ton per foot, respectively or not, as without insisting on this, a Government Inspector would probably not be satisfied that the precaution would always be observed when required

3 That the Secretary to the Committee be asked to take the subject up with the Engineering Department through the Technical Section

4 **Oil tank wagons** —That as other designs for these have been put forward, members be invited to submit descriptions and drawings of general arrangement of such wagons to the Secretary for publication in part III, "Notes and Correspondence"

5 **Height of sides of open wagons** —That the recommendations of the Sub Committee be adopted, and a note to this effect be entered on the republished drawing of the "Approved Design"

Goods Stock — Subject 5 A — Metre gauge

A—GENERAL ARRANGEMENT OF BODY—METRE GAUGE

The Sub Committee submitted the following report —

1 *General*—The Sub-Committee in its last year s report to the Madras Meeting made certain recommendations which were adopted by that meeting (*see Volume V, page 35 or Reprint of Business, page 109*) The work of the Sub Committee this year has been to prepare standard type drawings based on those recommendations

Single unit goods stock

2 (*a*) *Four wheeled covered wagons carrying gross loads of 12 tons (or say net loads of 8 to 9 tons)*—Since last year the Sub Committee has determined to recommend a length of 13 feet 3 inches (instead of 13 feet) over headstocks for the shorter wagon, as being exactly half the length of the double unit bogie wagon, the length of which has, for reasons given below, been increased For similar reasons the length of the longer wagon is also fixed at 15 feet 3 inches (instead of 15 feet) Standard type drawings for these four wheeled covered wagons are embodied in the Sub Committee's drawing No $\frac{4}{5\text{I}}$ presented herewith They have been drawn with the standard cross section adopted at the Madras Meeting (*see Volume V, page 37, and plate XVIII or Reprint of Business, page 113*)

(*b*) *Four wheeled open low sided and high sided wagons*—The lengths of these have also been fixed at 15 feet 3 inches the same as for the longer covered wagon In designing the low sided wagon to take full loads of ballast, it has been considered better to adopt a specific weight of 24 cubic feet per ton instead of 20 cubic feet as proposed last year It is found that for light stone ballast 20 cubic feet is too little Current practice for ballast wagon sides works out to about 24 cubic feet, and this results in the sides being 2 feet in height For the carriage of coal in the high sided wagon a specific weight of 40 cubic feet per ton has been adhered to, and the sides of the wagon are thus made 3 feet 6 inches high In accordance with latest practice in other countries however, it has been deemed well to provide a crib of open bars above the sides to enable the same wagon to carry a full or nearly full load of firewood, coke or sacks of grain Standard type drawings for these four wheeled open wagons are embodied in the Sub Committee s drawing No $\frac{5}{5\text{I}}$ presented herewith They conform to the same standard cross section as referred to above

(*c*) *Four wheeled bolster wagons*—No proposal was made last year for a bolster wagon and it is thought well to recommend two standard lengths of double bolster wagon one with an underframe 15 feet 3 inches long (same as the other goods wagons) and the other with an underframe 18 feet long (same as for the military covered wagon subject 10) These are shown in Sub Committee s drawing No $\frac{11}{5\text{I}}$ presented herewith The height of stanchions is fixed at 4 feet which will accommodate a full load of about 9 tons of timber Single bolster wagons working in pairs for carrying long timber are deprecated as being obsolete practice, bogie wagons being better adapted for such work and otherwise more generally useful

Double unit goods stock

3 (*a*) *Covered and open wagons*—On the resolution adopted last year the length of the shorter bogie covered wagon was to have been 26 feet (that is, twice the length of the four wheeler then fixed at 13 feet) Subsequently, however, it was pointed out by our

Goods Stock — Subject 5 B and C — Both gauges

B — CROSS SECTION OF BODY — BOTH GAUGES

Reference

Resolution adopted at Madras (*Volume V, page 37*)

See information recorded under subject 4-B, pages 42 and 43

C — FITTINGS — BOTH GAUGES

The Sub-Committee for the 5 feet 6 inch gauge submitted the following drawings for consideration of the General Committee —

No 132 Con End top flap door for 19 feet 3 inches wooden open side wagons made in pressed steel

No 1487 Con End flap doors made in pressed steel for iron open wagons

We put these forward as suitable designs for improvement in fittings

Label or ticket holders — A few samples of these will be submitted that will take labels, 5 inches × 3½ inches, with an exposed face of not less than 4¾ inches × 2¼ inches Stamped sheet iron recommended

R PEARCE
C T SANDIFORD
C E PHIPPS

See Part III, page 151 of this volume for correspondence on the subject wagon label holders.

Resolution adopted

1. That the drawings of end flaps for open wagons be published as "Approved Designs" (*see plate XXVI in this Volume*)

2. That label-holders be of sufficient size to hold a card, 5 inches by 4 inches, showing an exposed face of not less than 4¾ inches by 2¼ inches Provided they comply with this, it is immaterial to what extent the card projects above the top of the holder, or whether the latter be made of cast or stamped iron

SUBJECT No. 6.

UNDERFRAMES, including bogie trucks, axle-guards, buffing and draw-gear, and brakes and brake fittings. The design, proportions, dimensions, position and material for the same.

A.—Underframes. *C—Axle-guards*

B.—Bogies. *D—Buffing and Draw-gear.*

E.—Brakes.

A—UNDERFRAMES—5 FT. 6 IN. GAUGE.

Reference.

Resolution adopted at Madras (*Volume V, page 39*)

The Sub-Committee submitted the following drawing and report —

Standard 27 feet underframe built up of rolled sections

Mr. C. E. Phipps, member of the Sub-Committee, recorded the following objections to the standard 27 feet underframe put forward by the Sub Committee and submitted a drawing of 27 feet pressed steel underframe —

"I have not signed this drawing, as I do not approve of many of the details The frame does not seem to me to be sufficiently stayed, and I consider it should have diagonal bracing of some kind I further think that although an iron (built up) frame of an approved design might, if desired, be adopted for use where such is required, the standard carriage frame should be of pressed steel. This form of construction is now being very largely and generally adopted, and frames made in this material are, I think, certainly, weight for weight, far stronger than any form of iron frame. I consider further that at least four cross stays in addition to the headstocks are necessary in the frame to make a sufficiently rigid connection in a frame of the standard length of 27 feet."

Underframes, &c — Subject 6 A — 5 ft 6 in gauge.

Messrs C T Sandiford and R Pearce recorded the following objections to Mr Phipps' proposal —

Regarding the particular pressed steel underframe put forward by Mr Phipps we agree to submit to the General Committee but do not recommend it, as there are several points differing greatly from the original proposals To prevent misunderstanding, we remark that the details such as draw-bars, side chains wheels axles, and guards, etc, excepting buffers, having been provisionally and independently arranged for are not shown in these drawings

We agree with Mr. Phipps in thinking that a design should be considered for a pressed steel underframe and recommend that so long as the original design is not materially altered, a resolution be recorded to include a pressed steel frame This will probably be the frame of the future, combining as we believe it does the same strength with less weight

R PEARCE
C T SANDIFORD
C E PHIPPS

Resolution adopted

1 **27 feet built up frame.**—That the drawing of this be published as an "Approved Design" of frame for coaching stock (*see plate XXVII in this Volume*), details, such as design of axle-guards, etc, being dealt with separately

Mr Winmill records his objection that he considers a frame, 24 feet long, sufficient for I, II and composite vehicles (*see page 40*)

2. **Pressed steel frame.**—The Committee discussed the design for this, and consider that the use of diagonals is neither necessary nor advisable, and they interfere with the fitting of gas cylinders and the gear of the automatic brake

Underframe for bogie vehicles

The Sub Committee for the 5 feet 6 inch gauge also submitted drawings of 54 feet 4 inch built up underframe for bogie vehicles which is now being sent out for the East Indian railway, also for a similar frame in pressed steel

Resolution adopted

That the drawing of the 54 feet 4 inch built-up frame be published for information (not as an "Approved Design") as an example of what is being done in this direction (*see plate XXVIII in this Volume*)

A—UNDERFRAMES—METRE GAUGE

The Sub Committee for the metre gauge presented no report under this heading (*see Sub-Committee's reports on subjects 4-A and 5 A, pages 41 and 50*)

PRESSED STEEL UNDERFRAMES

With reference to the resolution adopted at Lahore on the subject of approved designs for underframes in pressed steel on the metre gauge (*see Volume IV, page 25*) and the paper by Mr Jones on the subject (*Volume IV, page 86*), a letter was read from Mr Jones pointing out that it had been found that the carriage underframes were not sufficiently stiff, due chiefly to the fact that the rigidity of the mild steel used had been overestimated In the case of carriage underframes of similar design ordered for the South Indian railway he pointed out that they had been used with a heavier load, and a greater distance between the bogie pivots than they had been designed for.

The frame designed for wagons had been found of sufficient strength, consequently the final results arrived at in the paper printed in Volume IV, page 86, were affected only to the extent of about 0 2 per cent The letter is printed at page 154 in this Volume

A paper by Mr Adler on this subject was also read The actual difference in weight between built up and pressed steel carriage frames, 38 ft 6 in long, was 270 lbs, and in the bogies 720 lbs in favour of pressed steel the built up frame cost £31 and the pressed steel £35 F O B in England, and the bogies, £32 and £29 16 0 respectively The great difference in weight and price of bogie-trucks is due to difference of design

In the case of the 26 feet wagon frames, the weight of the bodies is also included, the saving in weight of frame and body being 1,121 lbs in favour of pressed steel and in the bogies 485 lbs The cost of the frames is given as practically the same in both cases, the bogies costing £10-14-0 in built-up and £27-14-0 in pressed steel in this case also part of the difference in weight of bogie-trucks was due to difference in design, and the pressed steel underframe was considerably weaker than the built up one (*see page 156 in this Volume*).

Underframes, &c — Subject 6 B — Both gauges

B—BOGIES—5 FT 6 IN GAUGE

The Sub Committee submitted the following designs for bogie trucks and underframes —

Nos 1496 and 1497 Pressed steel bogie and built up underframe as being sent out for East Indian railway

No 1498 Pressed steel bogie and pressed steel underframe

They considered it safe to submit only designs known to have been accepted which are probably more useful for discussion than any abstract proposal

Resolution adopted

That the drawing of the pressed steel bogie with built-up underframe be published for information (not as an Approved Design) as an example of what is being done in this direction (*see plate XXIX in this Volume*)

B—BOGIES—METRE GAUGE

The Sub Committee for the metre gauge presented the following report —

1 *Bogie trucks with axle guards inside springs*—The Sub Committee has only to present the drawings for essential standard dimensions for bogie trucks with axle guards inside the springs, which it was found impossible to complete for last year's meeting as referred to in the last paragraph of its report on this subject (*see Volume V, page 40, or Reprint of Business, page 126*) The drawings now presented are —

For coaching stock	No	$\frac{2}{94}$
" goods	"	$\frac{3}{94}$

2 *Sectional contour of pivot plates*—Attention is drawn to the section in drawing No $\frac{2}{94}$ showing the contour for pivot plates of the bogie trucks for coaching stock It is identical with that adopted last year (*see Volume V plate XIX figure C*), but by an error, not detected till after the plate was in print the bottom plate was shown of one solid thickness instead of being fitted with a loose wearing washer occupying half its thickness, as now shown in the above drawing The use of such a washer is not essential but is recommended as in accordance with best latest practice It provides a ready method of adjusting the height of pivot bearings which have worn and at the same time it conduces to easy turning of the truck on its pivot with decreased liability to cutting and seizing The present drawing therefore should be taken in supersession of that in the plate quoted

NEGAPATAM,

26th October 1894

C E CARDEW (*Representative*)

C. E. CRIGHTON

C P. WHITCOMBE.

Underframes, &c. — Subject 6-B. — Both gauges.

Resolution adopted.

1. That the recommendations of the metre gauge Sub-Committee be accepted, and that the drawings of bogie-trucks with axle-guards inside frame be published as "Approved Designs," which may be adopted as an alternative arrangement to that shown in plates XIX to XXI of Volume V (*see plates XXX and XXXI in this Volume*).

2. That the design of pivot-plate shown in plate XXX be adopted in place of that shown in figure C of plate XIX of Volume V.

B.—BOGIES. — BOTH GAUGES.

Mr. J. J. Adler, Carriage and Wagon Superintendent, Rajputana-Malwa railway, submitted a paper on bogies for carriages, which is printed at page 161 in this Volume. He also exhibited photographs and models of his bogies.

C.—AXLE-GUARDS. — 5 FT. 6 IN. GAUGE.

Reference.

Resolution No. 1-B. adopted at Madras (*Volume V, page 41*).

The Sub-Committee for the 5 feet 6 inch gauge presented the following report —

We fully agree that it is very desirable to keep the old standard width of axle-guard $6\frac{5}{8}$ inches, and submit examples of axle-boxes in actual use fulfilling this condition (*see subject 7-C., page 75*).

Resolution adopted.

That the old standard of $6\frac{5}{8}$ inches between jaws of axle-guards be reverted to instead of $7\frac{1}{2}$ inches adopted at Lucknow (*see also Resolution 7-C, page 75 of this Volume*).

NOTE —Mr G Winmill recorded his objection that he considered $7\frac{1}{2}$ should be adopted in all new stock

It was pointed out that this would necessitate keeping two patterns of axle box in stock for many years to come

D—BUFFING AND DRAW-GEAR—5 FT 6 IN GAUGE

Buffers

The Sub Committee presented the following report —

The development or selection has practically reduced itself to the samples agreed to at the Lahore Meeting 1892 Any specimens since received are so closely like that it does not appear reasonable to debar their use.

Resolution adopted.

That the following "Absolute Standards" be adopted for buffers on 5 feet 6 inch gauge —

1 Spacing of bolt holes at base, when casing is bolted to headstock, 10 in by 5 in as adopted for the headstock at Lahore, and shown in plate XIII, Volume IV

2 Projection from headstock of buffer face when uncompressed, if straight headstock is used, 2 feet 1 inch, but this is not to prevent the use of shorter buffers when a bent headstock is used

3. Minimum diameter of face	13 inches
4 Maximum range of compression	5 inches
5 Diameter of spindle at buffer head	$2\frac{1}{2}$ inches
„ „ at spring	1 inches
6 Inside diameter of buffer casing where plunger buffers are used	8 inches full
Outside diameter of plunger	8 inches bare

7 That a drawing be published showing the "Absolute Standard" distance from bight of hook of draw bar to face of buffer (*see plate XXXII in this Volume*)

8 It is considered preferable that *all* buffers should be convex on the face, but where one is made convex and the other flat the flat one should be on the right hand side of a person facing the end of the vehicle

Dimensions of couplings when worn

Mr Pearce suggested that minimum dimensions should be fixed by the Committee and recorded

This subject was considered under the rules for the interchange of rolling stock at junction stations (*see subject 14 page 92 in this Volume*)

Underframes, &c — Subject 6 D. — 5 ft 6 in gauge

Standard coupling—5 ft 6 in gauge

It was pointed out that the coupling shown in plate I Volume III differs from that in use on most lines, in that the length of the blind portion at the centre of the screw is shown 3¼ inches, while in existing couplings it is only 2¼ inches

The reason for the alteration was not recorded at the Ajmere Meeting but it was purposely altered to prevent the screw jamming against either the hook or the shackle

Resolution adopted.

That the length of blind portion be altered from 3¼ inches to 3 inches, which is sufficient to prevent the screw jamming The chance of jamming decreases as the coupling wears

Springs for buffers and couplings

The Sub Committee for the 5 feet 6 inch gauge presented the following report —

We are of opinion that the spring is so important a detail that it cannot be left out of discussion, so draw attention to it and as the papers have formed the subject of a special reference it is hoped the members will come fully prepared to discuss it

A great deal of information on this subject, which had been collected by Mr Pearce, was laid before the meeting, *these papers are printed in part III page 164 of this Volume*

Resolution adopted

1 That for draw springs on 5 feet 6 inch gauge, the minimum range should be 2 inches and the maximum 3 inches

The minimum weight when steel is used should be 25 lbs and the maximum 35 lbs

2 *For buffer springs the minimum range should be 3½ inches and the* maximum 5 inches The minimum weight 35 lbs. and the maximum 50 lbs when steel is used

3 In both cases the spring should be fitted with a minimum initial compression of ½ inch, which should be in addition to the range of compression given, and should be capable of standing 5 tons when within ¼ inch of being home.

Underframes, &c — Subject 6 D — 5 ft 6 in gauge

4 That there is, in view of past experience, no reason to limit the choice of material to either steel or rubber, very good as well as very bad springs in both materials have at different times been supplied, the defects being due, in the case of rubber, to bad material, and, in the case of steel, to bad design and the springs being too light, in addition, in many cases, to bad material

5 The Committee deprecates the use of a stop, as this saves the spring at the expense of the frame, and if the springs be of proper quality the use of a stop is not necessary

6 The metre gauge members agree generally with the conclusions arrived at, but do not wish to bind themselves to the particular weights and strength specified, as the conditions of the buffing and draw gear on metre gauge are different from those on 5 feet 6 inch gauge

D.—BUFFING AND DRAW-GEAR — METRE GAUGE.

Buffer and Coupling and side-chains.

The Metre Gauge Sub-Committee submitted the following report:—

1. *General*.—The Sub-Committee has to report that early in the year a letter from the Secretary on this subject was received by its representative, Mr C E Cardew. This letter so clearly outlines the present state of this subject, showing what is still necessary to be done to put it on a satisfactory footing that the Sub-Committee here reproduces it with remarks on each of its paragraphs, printed in parallel columns for clearness and easy reference —

Secretary's No S 38 of 15 2 1894	*Sub Committee's remarks*
In Volume III, page 43, certain designs for metre gauge couplings and side-chains were accepted as *standards*. The drawings of these were exhibited at Lahore, and exception was then taken to certain details, as far as I can remember, as follows —	The Sub-Committee confirms this statement as correct.
(*a*) In the buffer and coupling a particular pattern of spring was shown, the use of which was not compulsory	(*a*) Correct so far as it goes, but the real objection was the fact of the illustrated spring being a patented invention of Mr I A Timmis, M. Inst, C E of Westminster
(*b*) The front and back spring casings were not interchangeable	(*b*) The real objection was that the springs were not arranged the same as in another drawing for vehicles with end platforms, exhibited at Ajmere but never published Thereby the transverse stiffness of springs for flexibility of buffers was less than in the unpublished drawing and less than desirable for coaching stock
(*c*) The alternative arrangement for lengthening the buffer on end platform vehicles was not shown	(*c*) Correct
(*d*) In the side-chains also this arrangement was not shown.	(*d*) Correct.
I think it was also stated that it had been arranged at Ajmere that the spring and buffer casings should be altered	Mr W R S. Jones expressed his willingness to do so.
It was therefore agreed that these drawings should be cancelled, and that Mr Jones should send revised ones to be published in Volume IV.	Correct.

Underframes, &c — Subject 6-D — Metre gauge

Secretary's No S 38 of 15 2 94	*Sub Committee's remarks*
About the time Mr Jones left India, drawings of a buffer and coupling of a slightly different design were sent to me, but no drawing of side chains.	No remark needed
The former drawing was published in Volume IV, plate XIV, but it apparently contains certain special features which are not desirable in an "Absolute Standard," and there is no drawing of side-chains I intended to bring this to notice at Madras but unfortunately overlooked it	No remark needed.
I now suggest that the Sub-Committee should take up the matter with the view to submitting a *drawing showing clearly what dimensions, etc, are* necessary for the "Absolute Standard," both for the buffer and side chains	Dealt with below in paragraphs Nos 2 and 3.
Perhaps the Sub Committee might at the same time draw the attention of the General Committee to the desirability of not including details in any "Absolute Standard," unless such detail is intended to be made absolute.	Dealt with below in paragraph No 4

Jones' Flexible Buffers and Screw Couplings

2 (*a*) *Faults of drawings previously published*.—In addition to the faults above summarised, it has since been reported to the Sub-Committee by Mr Adler, Carriage and Wagon Superintendent, Rajputana Malwa railway, that the published drawings of the latest type of Jones' buffer, adopted by the Committee as the new standard for India, do not provide sufficient range of transverse flexibility for long bogie vehicles To cure this fault, the following alterations are necessary —

(i) Reduction of depth of spring sockets and casings

(ii) Increase of diameter of same at mouth, making the sectional contour inside conical instead of cylindrical

(iii) Increase of diameter of hole in headstock to provide more clearance between buffer bar and the edge of hole when the bar is angled

(*b*) *Revised drawings*.—In the following revised drawings now presented, all the faults pointed out have been corrected —

No. $\frac{8}{14}$ Arrangement for vehicles without end platforms

" $\frac{9}{14}$ Arrangement for vehicles with end-platforms

" $\frac{10}{14}$ Details

The gear as now designed is in arrangement and in range of transverse flexibility the same for vehicles both with and without end-platforms The casings and sockets for the two arrangements are symmetrical in design though not actually interchangeable, which it was not found possible to make them compatible with otherwise satisfactory design As however interchange of these parts is rarely or never required, and renewals of them only necessary in rare instances, there would be little practical advantage in making them actually interchangeable.

(*c*) *Bay-mouthed Coupling hook*.—Opportunity has been taken of this revision of drawings to modify the mouth of the coupling hook, so as to form a bay in it equal in depth to the turn-under of the nose, as described and recommended in the paper by Mr C. E. Cardew (*published in Volume IV, page 143*) The advantage of this bay is understood in the

Underframes, &c — Subject 6-D. — Metre gauge

Secretary's No S 38 of 15 2 94	*Sub Committee's remarks.*
About the time Mr Jones left India, drawings of a buffer and coupling of a slightly different design were sent to me, but no drawing of side chains.	No remark needed
The former drawing was published in Volume IV, plate XIV, but it apparently contains certain special features which are not desirable in an "Absolute Standard," and there is no drawing of side-chains I intended to bring this to notice at Madras but unfortunately overlooked it	No remark needed
I now suggest that the Sub-Committee should take up the matter with the view to submitting a drawing showing clearly what dimensions, etc, are necessary for the "Absolute Standard," both for the buffer and side chains	Dealt with below in paragraphs Nos 2 and 3.
Perhaps the Sub Committee might at the same time draw the attention of the General Committee to the desirability of not including details in any "Absolute Standard," unless such detail is intended to be made absolute	Dealt with below in paragraph No 4

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No [illegible] Arrangement for vehicles without end platforms.

" [illegible] Arrangement for vehicles with end-platforms

" [illegible] Details

The gear as now designed is in arrangement and in range of transverse flexibility the same for vehicles both with and without end-platforms The casings and sockets for the two arrangements are symmetrical in design though not actually interchangeable, which it was not found possible to make them compatible with otherwise satisfactory design. As however interchange of these parts is rarely or never required, and renewals of them only necessary in rare instances, there would be little practical advantage in making them actually interchangeable.

(*c*) *Bar-mouthed Coupling hook*—Opportunity has been taken of [illegible] drawings to modify the mouth of the coupling hook, so as to form a bay [illegible] to the turn-under of the nose, as described and recommended in the paper by Mr [illegible] Cardew (*published in Volume IV, page 143*). The advantage of the bay is [illegible]

event of hooks getting slightly stretched by violent snatches in shunting operations (when the coupling is slack), and so losing more or less of the turn under of nose A number of these hooks have since been sent out from England and put in use on the Burma State railway with entire satisfaction It is perhaps only fair to say that the idea of this bay mouthed hook was taken from Messrs Luard and Lindsley's patent slack gathering coupling hook, used on the Gaekwar's State railway, although the bay itself was not one of the features covered by their patent

(*d*) *Stops for springs*—The Sub Committee wishes to point out that the latest form of Jones' buffer, as shown both in the published drawings and in the revised ones now presented, provides no stops on the buffer bar for limiting the stroke of the springs On all the older forms stops were provided, but they were done away with for three reasons so far as can now be ascertained —

(i) To enable a plain round buffer bar to be used

(ii) To obtain a slightly stronger spring by increasing the number of coils and decreasing the internal diameter

(iii) To save the headstocks from the punishment to which they were subjected by the old form of stops which exposed a very small area of bearing when in contact with headstock

During the year however the question of using stops for preventing damage to volute springs has been brought before the members of the Committee by Mr Pearce, Carriage and Wagon Superintendent, East Indian railway, and there are reasons for supposing that much of the trouble reported by him is traceable to the want of stops on the 5 feet 6 inch gauge It is therefore a question whether the use of stops should not be adhered to on the metre gauge There can be little doubt that the best form of stop is that of a self stopping spring, such as the new Timmis girder spring of which many hundreds are in use on the South Indian railway, and illustrated in Volume III plate III (*cancelled*) This drawing was objected to, because of the inclusion of a patent spring in a standard drawing of the Committee, and it was eventually cancelled and replaced by one showing an ordinary volute spring, which is not self stopping (*see Volume IV, plate XIV*) It is however a question whether Mr W R S Jones chief idea in adopting the Timmis girder spring was not the provision of a self stopping spring, and whether in surrendering the design he did not overlook this important point If therefore it be deemed well to provide stops the simplest and probably the cheapest plan will be to use some form of self stopping spring, which conforms to the essential dimensions of the standard spring (inside diameter of hole at apex and outside diameter of base) and is interchangeable with it If however a stop on the buffer bar be thought better the Sub Committee presents its drawing No [illegible] which provides stops on the plain round buffer bar composed of movable ferrules and washers which are the same for both arrangements of the gear for vehicles with and without end platforms It will be observed that this alternative design needs springs with a hole of 3¼" diameter inside at apex, which is the same diameter as that now universally in use The difference in strength between this spring and the modified one in the other drawings is trifling and hardly worth striving for Other things therefore being equal it must be considered an advantage to maintain the old size of spring in use Owing to the large hole in headstock necessitated by the latest type of Jones buffer gear any other form of stop than that now put forward seems to be inadmissible With these remarks the Sub Committee begs to leave the question of stops for settlement by the General Committee without making any definite recommendations, pending discussion of the whole question for both gauges on Mr Pearce's reference quoted above

Safety Side-chains.

3 To take the place of the design published in Volume III, plate 4 (endorsed for revision in Volume IV but not effected) the Sub-Committee now presents two drawings for

Underframes, &c. — Subject 6-D. — Metre gauge.

standard safety side-chains These show the arrangement and details for vehicles both with and without end-platforms, and for both metal and wooden headstocks No $\frac{9}{24}$ is for ordinary practice, and No $\frac{10}{24}$ for the application of Winter's system of electric communication between guard, passengers and driver, already largely in use in India The design for ordinary practice has been so worked out that all parts of it are adaptable in case it is desired to subsequently convert them for application of Winter's system The principal detail in this matter is the long and hollow back washer, which is made so that it can be filled with a non conducting plug of wood The employment of this long washer is found to be advantageous for preventing the eyebolts from drooping by the weight of the chains By its use also it has been possible to arrange one length of eyebolt for both wooden and metal headstocks The drawings being in detail need no further explanations, and all the details employed are on the lines of present existing practice

Absolute Standards

4 The Sub Committee recommends that the designs now submitted for approval be adopted as absolute standards It is strongly of opinion that absolute standards for buffing and draw gear are greatly to be desired As up to date there is also general uniformity of practice on Indian metre gauge railways, there is no obstacle to securing entire uniformity in future practice While, however, the Sub Committee strongly urges uniformity, and its attainment by the adoption of absolute standards, it does not mean to express an opinion that finality has been reached, either in the perfected development of the Jones' system, or in the possible invention of some other system as far superior to the Jones as that system unquestionably is to its predecessors and present rivals On the contrary the Sub Committee is of opinion that improvements of all kinds should be welcomed and invited, and that the adoption of an absolute standard has a tendency to stereotype acknowledged defects, and to stifle endeavours to remove them To therefore guard against any extension of this evil, which is unfortunately so characteristic of Indian railway working, the Sub Committee recommends that when the proposed absolute standard is adopted, a rule be at the same time adopted with it, that any modification of the present Jones system or the introduction of a new system of buffing and draw gear may be experimentally made by permission of the Committee to be obtained either by letter-ballot or by resolution at one of its meetings after the proposer has satisfactorily shown that the proposed modification or novelty possesses no objectionable mechanical features, will cause no difficulty in coupling up with the existing buffers, and is likely to prove itself to be an improvement on existing methods In such a case the following conditions must always be complied with —

(i) Buffer bars must be flexible with an angular range on either side of the centre line of one in 15 horizontally and one in 24 vertically

(ii) Buffer faces must be square with 11 inches side

(iii) The screw-coupling or slack gathering apparatus must be fixed on the female buffer or on both buffers *That on the female buffer must provide a range* not less than that of the standard screw-coupling and when in its slack position the contact face of its coupling block or pin must be at the same distance from the buffer face as in the standard buffer

(iv) The hook on the male buffer must conform to the standard hook in lengths in thicknesses, and in general contour of horn, nose and mouth

(v) No part of the buffing and draw gear must be less in strength and wearing surfaces than possessed by the standard gear

NEGAPATAM, C. E. CARDEW (*President* [illegible])

[illegible]th October 1894 C. E. C[illegible]

Underframes, &c — Subject 6 D — Metre gauge

Resolution adopted

1 **Buffing and draw-gear** —After full discussion the Committee have decided that a stop on the springs is neither necessary nor desirable (*see para 5 of resolution on page 61*)

2 That the Sub Committee's designs for buffing and draw gear without stops be accepted as ' Absolute Standards " and recommended to the Government of India to be adopted as such on all metre gauge railways subject to the reservations contained in paragraph 4 of the report of the Sub Committee (*See plates XXXIII and XXXIV*)

3. **Side chains** —That the two alternative designs for these, for ordinary use, and for use with Winter's electric communication be adopted as Absolute Standards," with either one or the other of which all side chains should comply (*See plates XXXV and XXXVI*)

Material for coupling hooks

Reference

Note by Mr C E Cardew (*Vol IV, page 143*)

Mr Cardew submitted the following reports by Sir A M Rendel for consideration by the Committee —

Copy of report by the Consulting Engineer dated 24th April 1894

We will try hard steel when next hooks are required for the Burma railway But it will be a new departure and I am by no means certain that it will cure the evil it is intended to meet, without introducing a greater

Experiments can be easily tried all over India with coupling hooks made out of scrap steel and the subject seems one for discussion by the next Locomotive and Carriage Committee

Copy of report by the Consulting Engineer dated 5th June 1894

Referring to my memorandum dated 24th April last on the subject of steel coupling hooks for the Burma railway I have now given instructions for the coupling hooks of the 12 buffers under contract 33—293 to be made of steel having a tensional strain of 35 tons per square inch with 25 per cent elongation to 42 tons per square inch with 20 per cent elongation or intermediate strains and percentages of elongation in proportion

Several members stated that they had used coupling hooks made out of both steel tyres and steel axles and had not found the material too hard in either case

SUBJECT No. 7.

WHEELS AND AXLES, including Axle-boxes and Springs. The designs, proportions, dimensions, position and material for the same.

A. Axles *C Axle-boxes*

B. Wheels. *D. Springs.*

A.—AXLES — BOTH GAUGES.

Reference.

Letter from the Secretary, No C 99 dated 27th September 1894, enclosing copy of report by Sir A M Rendel on the subject

In letter No 455 S dated Simla, 5th May 1892, the Director General of Railways referred to the Director General of Stores, India Office, London, for the opinion of the Consulting Engineer Sir A M Rendel, the Resolution adopted by the Committee at Ajmere in December 1891 printed in Volume III, pages 46 and 47 The following reply to this reference, in the form of a report by Sir A M Rendel, a copy of which had been circulated with Secretary s letter No C 99 dated 27th September 1894, was read,—

Copy of a Report by Sir A M Rendel dated London, 3rd July 1894

The proposed axle for 12 ton loads per axle has journals 4½" × 9", is 6" diameter at the wheel seat and 5¼" diameter in the centre

The axles I am now sending to the East Indian railway for 12 ton loads per axle have journals 4½' × 9", and are 6¼" diameter in the wheel seat and 5½' in the centre The e dimensions were arrived at after a trial on the East Indian railway, which led the officials of that line to conclude that an axle of the dimensions I have named was desirable for such heavy loads as 12 tons per axle, and bearing in mind that the load of the wagon may not always be equally divided between its axles they are perhaps right The difference in weight and cost between axles of the dimensions proposed by the Conference and those which I say are being supplied to the East Indian is so inconsiderable that I think the use of the heavier of the two ought to be well considered before the lighter one is determined on

There is some difference of opinion as to the proper standard for length I think that 7' 4" would be preferable if a new standard design for vehicles was under consideration, but as this is not so I think it would be better for each line to keep its own standard. Practically, all the broad gauge lines will have their axles 7 3" centres, and the Bombay-Baroda 7' 4"

Wheels, axles, &c — Subject 7 A — Both gauges

The metre gauge axle proposed has journals 3¼" × 7", is 4¾ in the wheel seat and 4¼" diameter in the centre This axle differs from those I have been recently sending to India in respect to the diameter in the wheel seat, which I have *made* 4¾", *as I prefer that* diameter, taking into account the risk of unequal loading

I would note in respect to paragraphs 3 and 9 (*of the Ajmere Resolution*) that we are now ordering exclusively, steel for our axles and that the breaking stress of the steel we use is fully one third greater than that of the iron (Yorkshire) we used to send

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The following protest by the Meter Gauge Sub Committee was also read —

Copy of the following telegram sent by the Metre Gauge Sub Committee while in session at Negapatam is forwarded for information in reference to the Secretary s Circular No 99 C, dated 27th September 1894

Negapatam, 26th October 1894 from M G S b Committee to Secretary Loco Co mittee

"Your letter No. 99-C Rendel already accepted Committee standard metre gauge axles by sending large number to Rajputana. Proposal to now alter standard so widely will cause most serious complications in effecting renewals Please move Government defer orders till after discussion at Calcutta meeting "

2 It is noted that Sir A M Rendel s proposal to increase the wheel seats of axles is ¼ inch in the 5 feet 6 inch gauge, and ⅜ inch in the metre gauge axle Further the largest diameter of wheel seat ever yet sent out by him in metre gauge wheels is only 4½ inch, that is ⅛ inch more than the Committee standard, which was deliberately reduced to 4⅜ inch after careful calculations at the Ajmere meeting in 1801

3 Further, the Committee standard has been accepted by Sir George Bruce the Consulting Engineer for the South Indian railway, who has sent out many hundreds to that line

4 If now we are forced to accept a 4¾ inch wheel seat for new axles it will involve the necessity for many years to come of boring out all wheels to the larger diameter—a very expensive and troublesome job

5 It is hoped that all members of the Committee will agree to support the undersigned at the Calcutta meeting in opposing this needless alteration of the present standard

NEGAPATAM, C E CARDEW (*Representative*)

26th October 1894 C E CRIGHTON

C P WHITCOMBE

The Sub Committee also submitted drawings of metre gauge axles which had been recently supplied to India

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Wheels, axles, &c — Subject 7-A — Both gauges.

Resolution adopted.

1. That in supersession of the dimensions adopted at Ajmere (*Volume III, page 46, and plates 6 and 7*), the following dimensions be adopted for new axles on the 5 feet 6 inch gauge as "Absolute Standards" —

	Standard length of journal	Standard diameter of new journal	Standard diameter of wheel seat.	Minimum diameter at centre
Heavy axle	9 inches	$4\frac{1}{2}$ inches	$6\frac{1}{4}$ inches	$5\frac{1}{2}$ inches
Light axle	9 inches	4 inches	$5\frac{3}{4}$ inches	5 inches

2 As regards distance between centres of journals, it is noticed that Sir A M Rendel now states that on the Bombay Baroda railway this will be 7 ft 4 in, and practically on all other broad gauge lines it will be 7 ft 3 in, whereas in his note dated 24th January 1894 (*see Volume V, page 113*) he stated that the Bombay Baroda railway should conform to the 7 ft 3 in standard adopted by other lines

3 This subject was very fully discussed at Madras (*see Volume V, pages 43, 44, and 110—113*), and it was then finally decided by a large majority of the broad gauge members to adopt the 7 ft 3 in standard, but in face of the opinion now recorded by Sir A M Rendel, the Committee hesitate to confirm this as an "Absolute Standard" The Committee also point out that this increase in length increases the bending of the axle, and it is understood that Sir A M Rendel has considered it desirable to increase the diameter with a view to reducing this bending

4 That as a substantial increase has been made in the diameter at wheel seat and at centre in the lighter axle, compared with the dimensions adopted at Ajmere, this axle be adopted as the standard for loads not exceeding 11 tons on a pair of wheels (including the weight of wheels and axles), subject to a minimum diameter of journal of $3\frac{7}{8}$ inches

5 On the metre gauge it appears that though axles having standard journals 7 inches by $3\frac{1}{4}$ inches, and wheel seats larger than $4\frac{3}{8}$ inches diameter, have been sent out by Sir A M Rendel to the Burma and Assam Bengal railways, and with journals $3\frac{1}{2}$ inches diameter to the Southern Mahratta, yet over 6,000 axles with wheel seats $4\frac{5}{8}$ inches in the rough, intended to be turned down to $4\frac{1}{4}$ inches for use in existing wheels, as well as 320 pairs of wheels with axles of the Committee's standard, complete, have been sent by him to the Rajputana Malwa railway, and 2,500 pairs of wheels with axles of the Committee's standard have been sent to the South Indian railway by Sir G Bruce, all of which are intended to carry the standard load

6 The Committee further notice that some of the axles with large wheel seats have a sudden change of section immediately behind the wheel seat, an arrangement which has previously been decided to be objectionable (*see paragraph 4* (*c*)

Wheels, axles, &c. — Subject 7-A. — Both gauges.

of the Ajmere Resolution, Volume III, page 46, also pages 142—144 in Volume II). This axle moreover is not appreciably stronger or stiffer than if the wheel seats were $4\frac{3}{8}$, the diameter of the axle immediately behind them.

7. In the axle adopted by the Committee, the stress on the metal in the wheel seat is about 10 per cent. less than that in the journal when the latter is *new* and of the *full* diameter of $3\frac{1}{4}$ inches, and when the journal is reduced to the minimum permissible of $2\frac{7}{8}$ inches it is over 50 per cent. less, and this proportion is the same whether the axle be symmetrically loaded or not.

8. The Committee also point out that the standard axles were finally adopted at Ajmere in December 1891, the general dimensions having been settled at Bombay in December 1890, that a copy of the resolutions and drawings appears to have been sent to Sir A. M. Rendel in May 1892, and they think that, if it was considered necessary to revise these standards, an intimation to this effect might have been given them earlier than September 1894, and that those who have to use the axles should have been consulted before any alteration, in a standard which they had adopted, was decided on Carriage and Wagon Superintendents on the metre gauge appear to be further from attaining one standard axle than they were three years ago.

Wheels, axles, &c. — Subject 7-A. — Both gauges.

of the Ajmere Resolution, Volume III, page 46, also pages 142—144 in Volume II). This axle moreover is not appreciably stronger or stiffer than if the wheel seats were $4\frac{7}{8}$, the diameter of the axle immediately behind them.

7. In the axle adopted by the Committee, the stress on the metal in the wheel seat is about 10 per cent. less than that in the journal when the latter is *new* and of the *full* diameter of $3\frac{1}{4}$ inches, and when the journal is reduced to the minimum permissible of $2\frac{7}{8}$ inches it is over 50 per cent. less, and this proportion is the same whether the axle be symmetrically loaded or not.

8. The Committee also point out that the standard axles were finally adopted at Ajmere in December 1891, the general dimensions having been settled at Bombay in December 1890, that a copy of the resolutions and drawings appears to have been sent to Sir A. M. Rendel in May 1892, and they think that, if it was considered necessary to revise these standards, an intimation to this effect might have been given them earlier than September 1894, and that those who have to use the axles should have been consulted before any alteration, in a standard which they had adopted, was decided on Carriage and Wagon Superintendents on the metre gauge appear to be further from attaining one standard axle than they were three years ago.

Wheels, axles, &c. — Subject 7-A — Both gauges.

Minima dimensions of axles in existing Stock.

The Sub-Committee for Subject 14, "Rules for Carriage Examiners," included certain dimensions for these in their draft of rules. As some of these dimensions appeared to be at variance with resolutions previously adopted, the matter was brought forward for discussion under this subject.

Resolution adopted.

That the following dimensions be adopted for the purpose of interchange of rolling-stock between different lines, not as standards for new axles.

Minimum diameter of axles.

(*N B* —Loads given are inclusive of weight of wheels and axles.)

5 FT 6 IN GAUGE JOURNALS 9 INCHES LONG.			METRE GAUGE * JOURNALS $6\frac{5}{16}$ INCHES LONG. † „ 7 „ „	
Minimum diameter of journal.	Minimum diameter at wheel seat	Maximum load that may be carried on each pair of wheels.	Minimum diameter of journal	Maximum load that may be carried on each pair of wheels
Inches	Inches	Tons.	Inches	Tons
4	6	12	†$2\frac{7}{8}$	6
$3\frac{7}{8}$	$5\frac{3}{4}$	11	†$2\frac{3}{4}$	$5\frac{1}{2}$
$3\frac{11}{16}$	$5\frac{1}{2}$	10	*$2\frac{5}{8}$	$4\frac{3}{4}$
$3\frac{1}{2}$	$5\frac{1}{4}$	9	*$2\frac{9}{16}$	$4\frac{1}{2}$

In the case of metre gauge axles there is no necessity to specify a minimum diameter at wheel seat, as there are no axles of which the strength at wheel seats is insufficient compared with that of the journals.

B—WHEELS—BOTH GAUGES

Wheel and tyre fastening.

Reference

Resolution adopted at Madras (*Volume V, page 46*)

The Sub-Committee for the metre gauge presented the following report —

The resolution (7-B 1) under which this Sub-Committee was appointed is printed in Volume 5, page 46

2 Resolution 7 B 2 also concerns this Sub Committee, *vide* Volume 5, page 47

3 With regard to the former resolution, this Sub Committee does not recommend the adoption, as a standard, of any other design of wheel centre than that hitherto used on metre gauge lines in India, namely, wrought iron rims and bosses, with "Kirtley" spokes Wheels with wooden centres are not considered suitable for general use in this country, experiment having demonstrated their unreliability, especially where the humidity of the atmosphere varies considerably, it is quite likely that metal disc wheels would furnish satisfactory results, but in the absence of precise information on the subject this Sub Committee prefers to adhere to the type of centre which has so far been found to answer the requirements of metre gauge lines

4 With respect to the tyre fastening a drawing is submitted showing the following designs —

(*a*) Stud fastening latest practice

(*b*) Glut fastening, *vide Proceedings, Volume V, plate XXII*

(*c*) Ring fastening

(*d*) Double ring fastening Stroudley and Carlton s

5 The systems illustrated under (*c*) and (*d*) are recommended by the Sub-Committee for adoption as approved designs both having been used on home railways to a large extent and being favorably reported upon

6 A tracing is attached to the ferrotype illustrating the four systems of fastening which shows a rolled section of tyre suitable to the four designs it is believed that no wheels have been obtained, by Indian metre gauge railways, with the glut system of fastening, but in any case the adoption of a standard rolled section of tyre will not be thereby affected, as the sections for the glut and ring fastenings correspond exactly, the rolled section shown in the tracing being applicable to all the designs, either of the two designs now recommended can be adopted by a railway, for new wheels, and only one section of rough tyre need be kept in stock for the old and new systems

HUBLI, J. J ADLER

November 1894 C P. WHITCOMBE

Wheels, axles, &c — Subject 7 B — Both gauges

On behalf of the 5 feet 6 inch gauge Sub Committee, Mr Carroll stated that no decision had been arrived at

Messrs Pearce and Sandiford consider that the stud has given satisfaction and proved itself a good fastener, and a condemnation of it would mean an enormous expense in tyres only partly worn out, for a standard under this head is not like that for a vehicle which may not be built for years, in the case of tyres it takes effect at once

Resolution adopted

1 That for each gauge the body of wheel be made a "Provisional Standard," as regards diameter and outline of rim

2 That a standard section of rolled tyre for each gauge be also adopted as a "Provisional Standard"

3 That for the 5 ft 6 in gauge the standards for rim and tyre shown on the drawing submitted by Mr Sandiford be submitted to ballot vote

These standards, which are shown in plate XXXVII are accepted by all the members representing the 5 feet 6 inch gauge except Mr Brock, on behalf of the Indian Midland and Mr Phipps on behalf of the Madras railway These railways have adopted the Mansell ring fastening shown in plate XXXIX, to which the standard section of tyre now adopted is not suited

4 That for metre gauge the standard shown on the Sub-Committee's drawings be accepted (*see plate XL in this Volume*), and that plates 8, Volume III, and 15, Volume IV, be cancelled, and plate 22, Volume V, be illustrative merely and not a "Provisional Standard"

5 That systems of fastening capable of being adapted to these sections be accepted, and that drawings of fastenings be published to illustrate these systems, not as approved designs (*see plate XXXVIII in this Volume for fastenings for 5 ft 6 in gauge and plate XLI for metre gauge*)

6 With regard to the note by Messrs Pearce and Sandiford, the Committee point out that no resolution has been recorded which condemns the use of studs in wheels already in use

7 With regard to spokes, the Committee consider that the open or "Kirtley" spoke has proved its efficiency and given general satisfaction That there is nothing against solid spoked wheels except their comparatively high price That disc wheels are in the experimental stage in India and at present their high price is against their general introduction As regards any combined construction of wood and iron, the Committee adhere to the resolution recorded in Volume II, page 44, that such a system is not suited to the variable climate of India generally, but may be adopted in special cases where the local conditions are favourable

Wheels, axles, &c — Subject 7 B — Both gauges

2 —*Minimum thickness of Tyres*

Reference

Resolution adopted at Madras (*Volume V page 48*)

Government of India s Circular No 5 Railway, dated 4th July 1894

OBSERVATIONS —In the revised schedules of standard dimensions for 5 ft 6 in and metre gauge railways, the following dimensions are laid down for wheels of vehicles —

	Gauge 5 ft 6 i	Metre
Item—(93) Minimum thickness on tread for tyres for passenger stock when worn	1¼ inches	1 inch
(94) Minimum thickness on tread for tyres for goods stock when worn	1 inch	⅞ inch

RESOLUTION —The Governor General in Council is pleased to direct that items Nos 93 and 94 of the revised schedules of standard dimensions be cancelled In future the authorities of each railway will be responsible that the thickness of tyres is not allowed to diminish beyond the point of safety, which should be fixed by them, in consultation with their professional advisers, by definite orders in regard to each class of tyre

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Messrs Pearce and Sandiford, members of the Carriage and Wagon Sub Committee for the 5 ft 6 in gauge submitted a proposal to increase the minimum thickness adopted at Madras (*Volume V, page 48*) for tyres of coaching stock and of goods vehicles with more than 9 tons on a pair of wheels this was opposed by Mr Phipps the third member of the Sub Committee, and withdrawn in accordance with rule 17 (*Old rules section 16 of new By Laws*)

The question of the best method of gauging this thickness was also discussed and referred to the Sub Committee for Carriage Examiner s Rules Attention is also invited to the report on the subject by the Master Car Builders Association (*see Part IV in this Volume*)

Wheels, axles, &c — Subject 7 C and D. — Both gauges

C —AXLE BOXES — BOTH GAUGES

The Sub Committee for the 5 ft. 6 in gauge presented the following report —

We fully agree that it is very desirable to keep the old standard width *of axle guard, viz* $6\frac{3}{8}$ inch, and submit samples of axle-boxes in actual use fulfilling this condition

Pressed steel axle box —We submit tracing No 1492 Con of axle box made in pressed steel, for consideration by the Committee This box complies in every way with our standard and can be made to suit either $6\frac{3}{8}$ in or $7\frac{5}{8}$ in guards as required

The great features about this box are, in our opinion, its lightness compared with the present cast iron box, and further that it is practically indestructible The box with clip weighs 54 lbs against 108 lbs for the cast iron, or exactly one-half The brass weighs the same in either case, so we have a total saving of nearly 2 cwts per vehicle deducted *from the dead and added to the paying weight, so that the box will pay for itself in a* very short time, apart from the large saving which would be effected in the present replacement of broken boxes not only in the cost of the boxes themselves, but in the delay to vehicles, and inconvenience and loss of traffic while under repairs

Sample boxes will be produced at the meeting, together with other steel boxes and the present cast iron box, and it is hoped that the Committee will be able to come to a conclusion on this important matter

R PEARCE
C SANDIFORD
C E PHIPPS

Resolution adopted

1. That the recommendations of the Sub Committee be accepted, as it has been found in practice that the width of $7\frac{5}{8}$ inches adopted for jaws of axle-guards at Lucknow is not necessary

2 From returns of broken boxes available it appears that the proportion of boxes broken is greater on those lines having a wide opening between axle-guards, than on those having a narrow opening While admitting that variation in design of box may partly account for this, it does not appear likely that a narrow opening increases the proportion of breakages

3 That drawings of steel boxes for both the 5 ft 6 in and metre gauge be published (*see plate XLII in this Volume for 5 ft 6 in and plate XLIV for metre gauge*)

8 That a drawing of the cast iron box in use on the North Western railway for $6\frac{3}{8}$ inch guards be published to illustrate the use of cast iron, in case anyone wishes to use it, in view of the comparatively high price of pressed steel boxes (*see plate XLIII in this Volume*)

NOTE —Mr Winmill records his objection (*see page 58*) He considers that $7\frac{1}{4}$ inches would be a better width for adopt fo new stock, as it gives more room for a well-designed box of cast iron.

D —BEARING SPRINGS — BOTH GAUGES

Nothing was brought forward under this head The Sub Committee for the metre gauge are invited to submit proposals for standards on that gauge

SUBJECT No. 8.

Standard dimensions to be adopted in cross section for Coaching and Goods stock from floor-level downwards, with reference to Floor-level, Buffer centres, Axle guards, Foot boards and the relative position of Station Platforms—

(i) *For the 5 ft 6 in gauge* { *A Coaching Stock*, *B Goods Stock* }

(ii) *For the metre gauge* { *A Coaching Stock*, *B Goods Stock* }

A—COACHING STOCK — BOTH GAUGES

Foot boards, 5 ft 6 in gauge

References

Resolution adopted at Madras (*Vol V, page 53*)

Government of India s Circular No 8 Railway, dated 28th September 1894

Enclosure to Government of India P W D, Circular No 8 Railway, dated 28th September 1894

The following alterations should be made to the Revised Schedule of Standard Dimensions to be observed on all 5 6″ gauge railways in India as prescribed in Government of India Circular No 5 Railway, dated 15th July 1892 —

For items (20), (21) and the note following them, *substitute*—

	Feet	In
(20 *a*)—Maximum height above rail level for *any* passenger platform	2	9
(20 *b*)—Minimum height above rail level for *high* passenger platforms	2	6
(21 *a*)—Maximum height above rail level for *low* passenger platforms	1	2
(21 *b*)—Minimum height for *any* passenger platform	Flush with rail level	

NOTE—No platform is admissible of any height between 1 foot 2 inches and 2 feet 6 inches above rails Every halting place must have a platform either raised or flush, which must be of standard platform length and ramped at ends. Flush platforms at unimportant halting places need not extend in width more than 16 feet from centre of track. Low platforms may have a curb instead of a platform wall, but a slope, falling towards the rails, steeper than 1 in 20 must not be used

Standard section from floor-level downwards — Subject 8 A and B — Both gauges

In diagram No 1 in the note regarding ' Carriage foot boards' for " Height above rails " and the figures below, *substitute*—

	Distance below floor level	
Upper foot board	1 ft	3 in.
Lower foot board	2 ft	9 in

Delete the head " Width across outsides " and the figures below

For the note which follows, *substitute*—

"The distance is to be measured to the upper surface of foot boards '

Width over steps

It was pointed out that though the words on the diagram regarding width over steps have been expunged, this is limited to 10 ft 0 inch by the *dimensions* on the diagram

Foot-boards, metre gauge

Reference

Government of India s Circular No 8 Railway dated 28th September 1894

The following alterations should be made to the Revised Schedule of Standard Dimensions to be observed on all metre gauge railways in India as prescribed in Government of India Circular No 7 Railway, dated 10th August 1892 —

For items (20), (21) and the note following them, *substitute*—

	Feet	In
(20 *a*)—Maximum height above rail level for any passenger platform	1	4
(20 *b*)—Standard height above rail level for new passenger platforms at important stations	1	0
(21)—Minimum height for any passenger platform	Flush with rail level	

NOTE —Every halting place must have a platform either raised or flush, which must be of standard platform length and ramped at ends Flush platforms at unimportant halting places need not extend in width more than 15 feet from centre of track Low platforms may have a curb instead of a platform wall but a slope, falling towards the rails, steeper than 1 in 20 must not be used

In diagram No 1 *substitute* the following for the note regarding carriage foot-boards —

" Every carriage is to be provided with one continuous foot board on each side, placed with its upper surface at a distance of 1 ft 2 in below floor level, the width across outsides of foot board being 8 ft 2 in '

Standard section from floor level downwards — Subject 8 A and B — Both gauges

Maximum height of Floor level, metre gauge

Reference

Government of India's Circular No 10 Railway, dated 18th October 1894

The following alteration should be made to the revised schedule of standard dimensions to be observed on all metre gauge railways in India as prescribed in Circular No 7 Railway of 1892

Item 87 —Maximum height above rail level for floor of any vehicle unloaded (with 2 ft 4 in wheels) *For* "3 ft 0 in" *substitute* "3 feet 1 in"

B —GOODS STOCK — BOTH GAUGES

Reference

Resolution adopted at Madras (*Vol V, page 53*).

Nothing was brought forward under this head

SUBJECT No. 9.

Any subject connected with the design of Coaching or Goods Stock which may, with the approval of the Committee, be brought forward for consideration or discussion in addition to those covered by Subjects Nos. 4 to 8.

A.—WHEEL BASE AND LENGTH OF VEHICLES.

Six-wheeled vehicles and radial underframes.

References.

Paper by Mr C E Crighton (*Vol. V, page 127*).

Paper by Mr C. E. Cardew (*Vol. V, page 128*)

Paper on radial underframes (*Vol V, page 178*).

Government of India Circular VI Railway of 6th July 1893 (*Vol V, page 55*).

The question of the wheel base of vehicles is referred to in the note by Mr J. R. Bell, printed at page 142, and considered mainly under subject 3-O, but with this exception, no new matter was brought forward under this head.

I.—REVISED CLASSIFICATION OF ROLLING STOCK

References

Government of India, P W. D, Circular No XIV Railway, dated 9th October 1893

Letter from Mr R Pearce, dated 22nd August 1894, to all Locomotive and Carriage Superintendents, enclosing two revised forms to replace Form XII in above circular

Letter from Mr R Pearce, No 260 Con, dated 15th November 1894 to all Locomotive and Carriage Superintendents

The form proposed by Mr Pearce was considered by the Committee and certain modifications recommended

Resolution adopted

That the form as now amended be circulated by the Secretary to all members for further opinion (*See Part III, page 185*)

SUBJECT No 10

Special designs, dimensions, fittings or arrangements for Coaching and Goods Stock to meet military requirements The desirability of uniformity on all railways of the same gauge, and, as far as practicable, on railways of both gauges, also the introduction of standard designs which shall meet military requirements without undue sacrifice of commercial considerations

GOODS WAGONS, MILITARY TYPE — METRE GAUGE

Reference

Resolution adopted at Madras (*Vol V, page 56*)

The Sub Committee for the metre gauge submitted the following report —

1 *Covered wagon* —In accordance with the resolution passed at the Madras Meeting (*Vol V, page 56 or Reprint of Business page 181*) the Sub Committee presents a drawing No $\frac{13}{84}$ for a metre gauge covered wagon of the same length as the corresponding wagon adopted for the 5 ft 6 in gauge (*Vol IV page 32 or Reprint of Business, page 181*) and giving accommodation for 4 full sized horses * The design as a whole is a combination of the best features of the wagons of this class now in use on the South Indian and Southern Mahratta railways, and in all respects provides equivalent accommodation to that given by the standard broad gauge wagon

2 *Open wagon* —In accordance with the same resolution an open wagon for the metre gauge was to be designed on the same lines as that approved for the broad gauge In adopting that resolution however the General Committee appear to have overlooked that at the 1890 meeting they adopted the report of the Sub Committee of that year against the provision of an open military wagon as the ordinary bogie low sided wagon sufficed for military requirements in the carriage of ordnance etc (*Vol II, page 36, subject 5 or Reprint of Business, page 179*) The present Sub Committee therefore considers it would be well for a few experiments to be made by the Military Department for settling whether bogie low sided wagons are really suitable If not, it will be a simple matter to prepare drawings for both 4 wheeled and bogie low sided wagons with drop ends on the same plan as that adopted for the 5 ft 6 in gauge (*Vol IV, plate VII*) It may however be noted that in any case bolster wagons with their bolsters removed could always be employed for carrying ordnance, and wagons with drop-ends would only be needed where bolster wagons were not available in sufficient numbers The Sub-Committee would have prepared drawings for wagons with drop ends but found its time insufficient for the purpose

C E. CARDEW (*Representative*)
C E CRIGHTON
C P WHITCOMBE

NEGAPATAM,
26th October 1894

* *This should apparently be 61 wagons 9 feet wide over body carry 8.*

Military requirements — Subject 10 — Both gauges.

Resolution adopted.

1. **Covered wagon.**—That the drawing submitted is not altogether satisfactory, and that a fresh design, following as nearly as possible that adopted on the 5 ft. 6 in. gauge, be submitted.*

2. **Open wagon**—That for this, the Secretary submit to the Government of India for approval the design of open bogie low-sided wagon accepted by this meeting (*see page 51 and plate XXII in this Volume*).

Maximum gross weight on a pair of wheels.

Resolution adopted at Madras (*Vol. V, page 57*).

Attention will be drawn to this resolution when the design for the covered wagon, military type for metre gauge, is submitted.

* A revised design has since been sent to the Secretary by the Sub-Committee and submitted by him to the Government of India for consideration.—F. W. D

SUBJECT No 11.

Automatic Vacuum Brake for Railways in India

STANDARD CONNECTIONS — 5 FT 6 IN GAUGE

The Sub Committee submitted the following proposal for consideration —

Standard position of the dummy gland—A proposed new standard position of the dummy gland is suggested the present standard, 2 ft 6 in from buffer face to centre of pin of dummy (*see Vol II plate 35*) is too far back the hose pipes slip off and 1 ft 11 in is suggested as the standard

Resolution adopted.

The Committee consider that a distance of 2 feet is preferable and should be adopted as a standard in future instead of 2 ft 6 in This alteration does not in any way affect the standard of the connection itself

STANDARD CONNECTIONS — METRE GAUGE

Reference

Resolution adopted at Madras (*Vol V page 58*)

The Sub Committee for the metre gauge submitted a drawing of the arrangement proposed for the hose pipe coupling on the metre gauge

Resolution adopted

The Committee notice that the length of hose pipe in the proposed metre gauge connection is not the same as adopted on the 5 ft 6 in gauge Reasons for adopting this length were given in paragraph 13 of the report of the Sub-Committee, Vol II, page 51

The Sub Committee for the metre gauge should therefore reconsider their proposal

Automatic Vacuum Brake — Subject 11 — Both gauges.

WORKING OF THE BRAKE

Reference.

Secretary's letter No C 96, dated 10th August 1894 (*see page 194 in this Volume*).

Abstract of replies received to Secretary's letter No C-96 —

The Eastern Bengal, East Indian, Great Indian Peninsula, North Western and Oudh and Rohilkhand railways report that the brake has worked most satisfactorily, nearly all failures or delays being due to the inexperience of the staff, or to obstructions on the line

The Bombay-Baroda and South Indian railways report that the brake has only recently been brought into use

The Bhavnagar-Gondal, Bengal-Nagpur, Burma, Indian Midland, Nizam's State, and Southern Mahratta railways report that the brake is not in use on their lines

Mr Pearce expressed the opinion that the question should be referred to the vacuum brake sub committee

The following railways have not replied —

Bengal and North Western, Madras, and Rajputana-Malwa railways

The Locomotive Superintendent, North Western railway, reports —

1 I may state that most of the delays put down to the brake were due to the inexperience of the staff It cannot be expected that thousands of ignorant natives will at once do the right thing, and even with European train staff, there is a good deal to learn, the enginemen do, I believe, understand the brake

2 Another difficulty on the North Western railway is that on the whole of the line, from Kurrachee to Peshawar and Ghaziabad, there is not a single examining pit and it is all but impossible to expect that the brake can be looked after properly when men can only examine it by crawling on their bellies under the vehicles, and as we have a good many bogies, only a thin man can get in There is an objection held by our Manager to a pit on a platform siding but it is the only place for it on a through running train, and if not more than 2 ft to 2 ft 6 in deep from rail level, I see no objection the East Indian railway have actually put them in at Delhi Allahabad, etc.

3 The brake is and always has done very well and given satisfaction and the only point in which I see danger is its use on mixed trains where the proportion of unbraked wagons is so great that it is likely to lead to disastrous results I am of opinion that a rule, such as is in force at home, should be introduced here, *viz*, that the number of unbraked vehicles shall not exceed a fixed proportion, say one third As it is we may have 20 loaded wagons, gross say 400 tons unbraked, and 5 to 10 braked carriages, gross 60 to 100 tons

The Locomotive Superintendent, Great Indian Peninsula railway, reports that 275 618 miles were run by trains fitted with the continuous automatic vacuum brake on his railway during the 6 months ending June 1893 with no cases of failure, or partial failure, to stop a train when required

Automatic Vacuum Brake — Subject 11 — Both gauges

2 There were, however, 11 cases of small delays reported, of which two only exceeded 8 minutes The delays in the aggregate amount to one hour and twenty four minutes only, and they are very trivial when compared with delays which result from other causes in ordinary train working Six of these cases are reported to have been caused by the neglect of servants these were suitably taken up at the time The delays attributable to failure of material were chiefly due to India rubber hose pipes and washers having perished with the climate

3 None of the cases point to any serious defect or deficiency in the brake apparatus, and it will be noticed that no delay or difficulty was experienced on the Ghaut Section between Lonauli and Kurjat

4 The general result of the half year s working has been, in his opinion very satisfactory, and the train staff have every confidence in the brake as a reliable and efficient means of stopping their trains

The Locomotive Superintendent, Eastern Bengal State railway, states that the continuous automatic vacuum brake has been in use since 1888 on the standard gauge and from the first half of the current year on the metre gauge portion of his railway

2 The number of engines and rolling stock fitted with the brake for the standard gauge up to the present time is 15 and 104 respectively, and the number of vehicles supplied with train piping is 31 the number of engines and vehicles fitted on the metre gauge is 4 and 59 and the number supplied with train piping is 7

3 There has been no failure on record of these brakes since the r introduction on his line, and the actual working of them generally has been most satisfactory

4 He notes the number of failures of the brakes on other railways using them as shown in table II of the enclosure referred to and agrees that the question of what steps should be taken to reduce such a number might with advantage be discussed at the next meeting

Resolution adopted

The Committee as a body consider that the brake is working satisfactorily They would draw particular attention to paragraphs 2 and 3 of Mr Sandiford's report

SUBJECT No. 12.

An efficient system of communication in trains suited to the conditions of railway working in India.

Reference.

Resolution adopted at Madras (*Vol. V, page 59*).

No reports were received from the Sub-Committee.

Resolution adopted.

That the attention of the Sub-Committee be invited to the resolutions adopted at Madras, as well as at previous meetings. No report on the subject, as a whole, has yet been laid before the General Committee.

Side-chains for Winter's system.

The Metre Gauge Sub-Committee for carriages and wagons submitted designs for these, see pages 65—66 and plate XXXVI in this Volume.

SUBJECT No. 13.

Improvements in the lighting of railway carriages, and the plant, fittings and appliances required for the same.

Mr. E. B. Carroll presented the following report on behalf of the 5 ft. 6 in. gauge Sub-Committee:—

The Sub-Committee agrees that there can be no report of *results* worth having at present, and I submit the following brief statement of the progress of gas lighting on the leading railways, which may be inserted in the proceedings as before:—

E. I. R.	Now have gas on all mail trains.
N. W. R.	Not yet decided to introduce gas, or make any change in the present system of lighting.
G. I. P. R.	Fittings for gas have been received, and the work is now in hand.
Madras R.	Materials and fittings for Pintsch's gas expected this year.
B. B. & C. I. R. ...	Materials and fittings for Pintsch's gas expected this year.
I. M. R.	Fittings for Pintsch's gas indented for.
E. B. S. R.	Has decided to use Pintsch's gas. Sanction to expenditure is awaited.
B. N. R.	No steps taken to introduce gas.
O. & R. R.	Has decided to use Pintsch's gas, but indents for material have not yet been sanctioned.
N. G. S. R.	Nothing yet decided ; two carriages are fitted with gas which is obtained from the Great Indian Peninsula Railway.

Lighting Railway Carriages — Subject 13 — Both gauges

The Metre Gauge Sub Committee reported that no definite progress has been effected n metre gauge railways since the meeting of the General Committee in December last

2 The present position on the several metre gauge lines is as follows —

R M. R .	Estimates for the introduction of Pintsch s system of lighting by oil gas were submitted in 1891, but have not yet been sanctioned
E B S R	It has been practically decided to adopt Pintsch s system, and estimates were submitted some months ago
S M R .	Estimates for the introduction of Pintsch s system have been called for, and are under preparat on
B G J P R .	No alteration has been made in carriage lighting arrangements during the current year
S I R.	No steps have been taken since last meeting
B & N W R	Using castor oil, no present intention of making any change
B S R	Using petroleum of 250° flashing po nt which affords satisfactory results

HUBLI,
November 1894

J J ADLER
C E CARDEW
C P WHITCOMBE

The Comm ttee inspected the apparatus for the manufacture of the gas at the Howrah vorkshops The use of gas on the East Ind an railway had so far given complete satisfac- on The amount of light is far greater than with the old oil lamps, even when the latter re properly trimmed and the gas can readily be lowered by the passengers when not equired and turned up or down by the guard without delay

SUBJECT No 14

Rules for the guidance of Carriage Examiners at Junction Stations with full instructions on the following subjects —

(*a*) *The standard dimensions material, design &c for such parts of each class of vehicle as it may be the duty of the Carriage Examiner to inspect*

(*b*) *Standards which are absolute and admit of no exception*

(*c*) *Standards in regard to which exceptions are permissible and to what extent, under what conditions and subject to what restrictions these exceptions may be passed*

(*d*) *The assessment of the value of repairs done on stock belonging to foreign lines*

Reference

Resolution adopted at Madras (*Vol V, page 62*)

The Sub Committee submitted a final draft of the rules also a précis of objections raised by Locomotive Superintendents with opinions of the Sub Committee on the same

Resolution adopted

1 That the following draft, as amended by the General Committee, be accepted as a set of rules concerning the interchange of coaching and goods stock at junction stations, to form a basis for rules for the guidance of Carriage Examiners at such stations

2 That the Sub Committee continue their labours, and prepare a set of rules for the guidance of Carriage Examiners, which shall contain descriptions and drawings of the gauges to be used by them

RULES CONCERNING THE INTERCHANGE OF

Coaching and Goods Vehicles at Junction Stations

to form a basis for

Rules for Carriage Examiners at such stations

1. *Rules adopted by the Railway Conference of 1888 and 1893.*

(*a*) So soon as the rolling stock of any railway passes into the custody or possession of any other railway, such other railway shall be responsible for all and every contingency that may arise from the use of such stock while it remains in its possession Except that, if the contingency is clearly traceable to defect of material or workmanship, the actual repair or replacement of the vehicle in which there was such defect but not of any other vehicle or any other consequent damage, shall be at the expense of the parent railway

(*b*) The cost of repairs arising from ordinary wear and tear shall always be borne by the parent railway, but in cases of palpable damage (such as dropping heavy weights into wagons and so damaging the bottoms, neglect of greasing or oiling, and other similar neglects), and in all cases of accident or collision the cost of repairs shall, except as provided in clause (*d*) of this regulation, be borne by the railway in whose custody or possession the stock may be at the time the damage occurs

(*c*) No claim for the cost of repairs shall be valid unless made within three months of the date at which the repairs are completed

(*d*) The cost of repairs to any vehicle damaged, which does not exceed ten rupees, shall be paid by the railway which carries out the repairs

(*e*) No charge shall be made for the freight of material sent for repair of damaged stock, nor for the haulage and mileage of wagons carrying damaged stock back to the parent railway, but such wagons shall be subject to ordinary demurrage charges

2 Vehicles shall be delivered in good running order and returned in the same general condition as when accepted

3 A careful inspection of each vehicle must be made at the junction station by the Carriage Examiners of the railways concerned, a return on the form prescribed (*vide* Appendix A, page 91), with all defects noted, being furnished for every train passing the junction, and Nil returns should be submitted where no defects are noted

4 Vehicles may be refused under the following circumstances —

(a) Maximum moving dimensions as sanctioned by the Government of India and as shown under standard loading gauges being exceeded (*See paragraph 5*)

(b) Absolute standard dimensions as sanctioned by the Government of India or adopted by this Committee being infringed (*See paragraph 6*)

(c) Absence from passenger stock of continuous footboards or hand rails

(d) Existence of defects likely to endanger safe running (*See paragraph 7*)

(e) Existence of defects rendering vehicles in any way objectionable for the conveyance of passengers or goods (*See paragraph 8*)

(f) When overloaded or unevenly loaded (*See paragraph 9*)

5 The maximum moving dimensions sanctioned by the Government of India are shown in Appendices B and B_1, pages 95 and 96

6 The absolute standard dimensions concerned in the interchange of stock, as sanctioned by the Government of India are as follows —

Wheel Base

	5 ft 6 in Gauge Feet	5 ft 6 in Gauge Inches	Metre Gauge Feet	Metre Gauge Inches
(a) Maximum rigid wheel base for passenger vehicles	16	0	12	0
(b) Do do goods vehicles	12	0	10	0
Buffers and Couplings				
(c) Maximum height above rail level for centres of buffers of unloaded vehicles	3	$7\frac{1}{2}$	1	11
(d) Minimum height above rail level for centres of buffers of loaded vehicles	3	$4\frac{1}{2}$	1	9
Wheels and Axles				
(e) Standard wheel gauge or distance apart for all wheel flanges	5	3	3	$0\frac{5}{8}$
(f) Maximum projection for flange of tire below rail level	0	$1\frac{3}{8}$	0	$1\frac{1}{4}$

In addition to the above the following standards adopted by the Committee must be observed —

	Feet	Inches	Feet	Inches
(g) Minimum thickness on tread for tires when worn if fitted with continuous ring fastenings	0	1	0	$\frac{3}{4}$
(h) Do do if not fitted do	0	$1\frac{1}{4}$	0	$\frac{7}{8}$

(i) Minimum diameter of axles for coaching and goods stock.

N B —Loads given are inclusive of weight of wheels and axles

5 ft 6 in GAUGE JOURNALS 9 INCHES LONG			METRE GAUGE. * JOURNALS $6\frac{9}{16}$ INCHES LONG † 7 INCHES LONG	
Minimum diameter of journal	Minimum diameter at wheel seat	Maximum load that may be carried on each pair of wheels	Minimum diameter of journal	Maximum load that may be carried on each pair of wheels
Inches.	Inches	Tons	Inches.	Tons
4	6	12	†$2\frac{7}{8}$	6
$3\frac{7}{8}$	$5\frac{7}{8}$	11	†$2\frac{3}{4}$	$5\frac{1}{4}$
$3\frac{11}{16}$	$5\frac{1}{2}$	10	*$2\frac{5}{8}$	$4\frac{7}{8}$
$3\frac{1}{2}$	$5\frac{1}{4}$	9	*$2\frac{9}{16}$	$4\frac{1}{2}$

7 The principal defects likely to endanger safe running are —

Axle-boxes — (a) Seriously damaged (b) Insufficiently packed or oiled.

Axle brasses — (c) Excessively worn. (d) Overheated.

Wheels — (e) Loose on axle (f) Out of gauge

Wheel tires— (g) Loose cracked or broken

(h) Worn or turned too thin, i.e., below the dimensions entered against 6 (g) and 6 (h)

(i) Excessively worn on tread i.e. more than $\frac{3}{16}$ inch (*vide Appendix C*)

(j) Sharp or thin flanges, i.e. less than $\frac{7}{8}$ inch (*vide Appendix C*)

(k) Having flat places exceeding 3 inches in length or width on 5 ft. 6 in. gauge or 2 inches on metre gauge.

Axles— (l) Bent or cracked

(m) Journals worn too small, i.e., less than permissible under paragraph 6 (i)

Springs— (n) Broken or weak, so as to permit flange of wheel to come within $\frac{3}{4}$ inch of bottom of wagon when standing

(o) Attachments excessively worn.

Draw and buffer gear—(p) Springs broken

(q) Cotters, nuts or split pins missing or defective

(r) Draw bars excessively worn, for 5 ft. 6 in. gauge, or below $1\frac{3}{8}$ inch diameter for metre gauge

Couplings— (s) Pins, shackles, links or hooks of couplings, worn; these should be condemned if less than 1 inch at any wearing part

(t) Nuts washers or split pins at the ends of the pins or screws missing.

(u) Chain or screw for securing hook defective.

Brake - - - (v) Blocks worn out

(w) Levers blocks pins or gear requiring adjustment

(x) Brake screw or nut worn out or unserviceable

8 The principal defects rendering vehicles objectionable for the conveyance of passengers or goods are —

(*See para 11*)

(a) Leaky roofs or tanks

(b) Dirty condition.

(c) Cushions dirty or damaged

(d) Windows shutters or their fittings defective

(e) Doors or door fastenings defective

9 Uneven loading can be detected sometimes by the appearance of the load, sometimes by the difference in the heights of vehicle ends Overloading can best be detected by the appearance of springs in cases open to doubt vehicles should be passed over the weigh bridges

10 The attention of the Station Master concerned should be directed to any vehicle which is unevenly loaded or overloaded in order that the load may be adjusted or reduced Particulars of such cases should be entered in the damage returns

11 First and second class carriages if occupied when passing junctions, should not be examined inside, to the discomfort and annoyance of passengers, nor can horse-boxes if filled with horses or cattle be inspected internally In such cases a note to the effect that a vehicle has not been examined should be made on the examination report, so that on return to the parent line internal defects may not be charged for

12 In all cases of foreign stock *stopped* for repairs the form given as Appendix D (page 98) must be filled up and furnished at the end of each week to the Locomotive or Carriage Superintendent of the line executing the repairs

13 Particulars of any slight repairs done to foreign stock on *passing trains* should merely be entered in damage returns

14 No extensive repairs of foreign stock must be executed by Examiners, but only sufficient to enable vehicles to run back to the parent line

15 Any foreign stock arriving at other than interchanging stations with damages that will probably take more than six days to repair, must be handed over to the Traffic Department for return to the parent line Should such damages affect the safe running of the stock the Carriage Examiner must of course take the necessary steps to make the vehicle fit to travel before handing it over to the Traffic

16 Repairs arising from ordinary wear and tear, such as changing wheels for thin tires, replacing axle boxes brasses or other fittings, should not be executed if the Examiner considers the vehicle fit to run back to the parent line

17 In cases where wheels springs, axle boxes, brasses or other fittings require to be changed, the materials must if not in stock, be telegraphed for In asking for materials full particulars should be given, and also the numbers of the patterns if any

18 Materials for the repairs of vehicles on foreign lines will be kept at different junction stations as agreed upon by the several railways from time to time —See sample list in Appendix E, page 99

19 In cases of collision, accident &c, in which foreign vehicles are seriously damaged, the debris must be immediately loaded up and despatched to the owning company, advice being sent to the Locomotive or Carriage Superintendent of the line on which the accident has occurred

20 All broken or damaged materials belonging to foreign railways should be returned to the owning railway through the Examiner at the nearest interchanging station

21 The attention of the Station Master and Guard should be called to any screw couplings not tightly coupled up

22 Wagons are not to be lifted when loaded, but the Traffic Department should be asked to tranship the contents An exception to this rule may be made in cases where the total load in a wagon does not exceed one fourth of its carrying capacity

23 When lifting vehicles or examining axle boxes, particular care is to be exercised in the examination of journals if any defect is noticed the vehicle must be stopped and such further action taken as may be requisite

24 All damages must be at once brought to the notice of the Traffic Staff, and, in case it should be necessary to cut off a vehicle advice must be sent to the Station Master concerned on the form shown in Appendix F, a second copy of this form must be filled up and sent to the Station Master when the vehicle is repaired and ready to be returned to the Traffic

25 When any deficiencies or damages are discovered in vehicles, caused apparently by theft or through mischief, Examiners should at once give notice to the Railway Police, and should also inform the Station Master and Guard concerned

26 A schedule of prices to be charged for damages done to vehicles by passengers or troops is given in Appendix G, page 101

(a) Should any damages occur, the cost of which is not included in this schedule, the Examiner should assess the value in conjunction with the Station Master

(b) On arrival of trains conveying troops at terminal junction, halting or Guard's changing stations, the damages should be noted without delay and brought to the notice of the Guard and Station Master

27 A schedule of rates to be charged for repairs to foreign stock is given in Appendix H, page 104

APPENDIX A

________________ RAILWAY.

No ______

Return of damaged vehicles

______________ *Station.*

__________________ 189

We have examined the following trains this day, and find the undermentioned vehicles damaged —

No of Train				Nos of vehicles	Owner	Description of stock	Nature of damage
From	Ry	To	Ry				

(Note — This form is in quadruplicate No 1 to be retained by the Carriage Examiner No 2 to be handed to the Station Master No 3 to be sent to the Carriage Superintendent of the home line and No 4 to the Carriage Superintendent of the Railway owning the damaged vehicle)

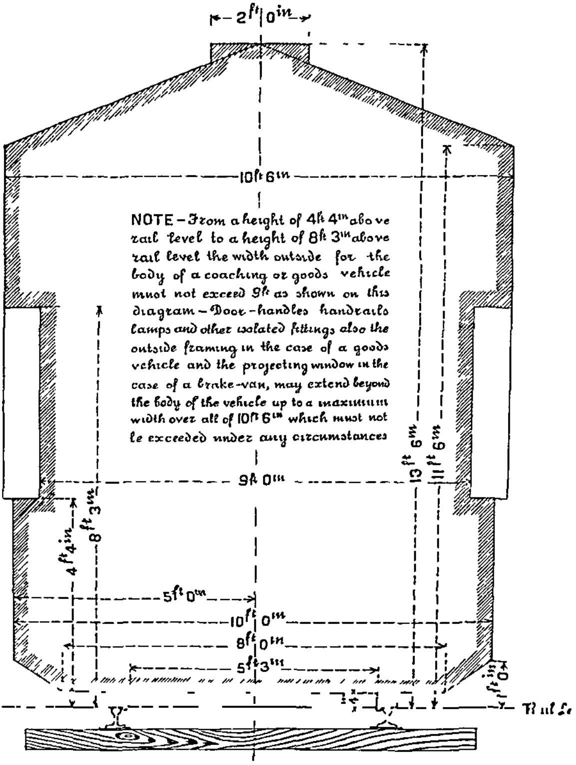
__________ *Carriage Examiner,* __________ *Ry (examining).*

__________ *Carriage Examiner,* __________ *Ry (owning)*

This return must be sent in daily and all trains whether or Railway must be entered herein If there are no damaged vehicles, "Nil" must be entered against the train

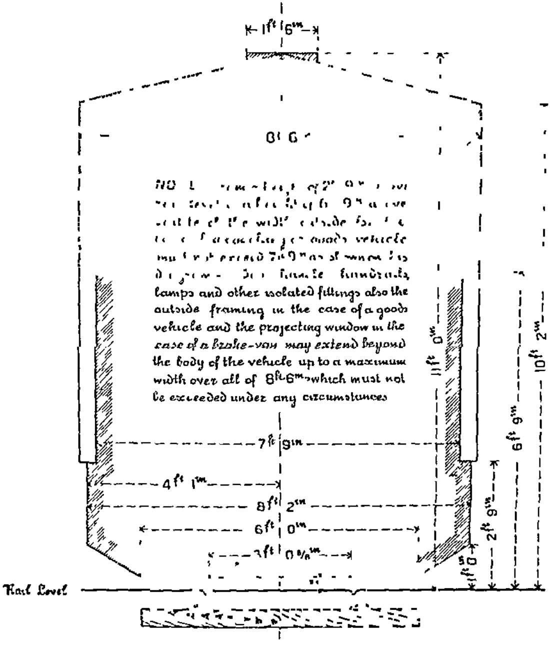
APPENDIX B

Diagram of maximum moving dimensions—5 ft 6 in gauge



APPENDIX B-1

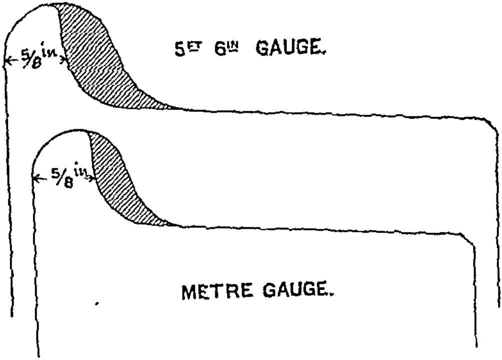
Diagram of maximum moving dimensions—Metre gauge



APPENDIX C

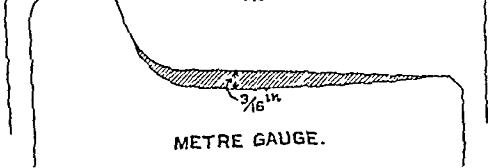
Limits of wear for Wheel Flanges.—Both gauges.

The hatched line shows how thin flanges may be worn, provided the edge is *round* and *not knife edged*



Limits of wear for Tread of Wheel.—Both gauges

Maximum tread wear shown hatched.



APPENDIX D.

________________RAILWAY.

*No.*______

*Return of Foreign Vehicles repaired at*________________*Station,*
*Week ending*____________*189* .

Date stopped	Date repaired and Traffic advised	Number and kind of Vehicle.	Owning Company	Nature of repairs executed and materials used and labour expended	Remarks as to how, when, and where damaged, and from what cause.

This form is to be filled up weekly, for week ending Saturday midnight, and forwarded per first train to the office of the Carriage and Wagon Superintendent.

Carriage & Wagon Supdt. *Foreman.*

APPENDIX E.

Sample List (pro formâ) *of*
Spare Gear for Repairs of Foreign Stock kept at Junctions

Owning Railway	Junctions at which gear is kept	List of Gear.	
		Number of parts kept.	Description
Madras Railway	Raichur ...	4	M R C axle boxes.
	" .	2	M R axle-boxes
	"	2	Springs for passenger vehicles
	" .	4	Do for goods vehicles
	Wadi .	2	M R C axle-boxes
	" .	1	M R axle-box
	" ..	1	Spring for passenger vehicles
	" .	2	Springs for goods vehicles
Great Indian Peninsula Railway	Raichur	3	Axle boxes
	" ..	3	Springs for passenger vehicles
	" ...	6	Do for goods vehicles
	Itarsi .	4	Axle boxes
	"	12	Springs for goods vehicles.
	" .	6	Do for passenger vehicles
		&c	&c &c

NOTE —Lists in a form similar to this sample to be filled up from time to time and submitted by and to the several railways concerned for record and for information of Carriage Examiners and others.

APPENDIX F.

RAILWAY

No.

Returns of vehicles cut off trains as unfit to run or re-issued to Traffic as fit to run

189 .

The Station Master *Station*

Please note the following vehicles

are now *unfit* / *fit* *for use.*

No	Description	Owning Company	REMARKS

Carriage Examiner.

APPENDIX G

Schedule of charges for damages to vehicles by passengers or troops while travelling by railway

Item.	Description	Rates for 5 ft 6 in. gauge			Rates for metre gauge		
	PASSENGER VEHICLES	Rs	A	P	Rs	A	P
	Door of carriage destroyed—						
1	First class side	45	0	0	30	0	0
2	,, end	...			20	0	0
3	Second class side	30	0	0	30	0	0
4	end				20	0	0
5	Third class side	18	0	0	20	0	0
6	end				15	0	0
	Door of carriage seriously damaged—						
7	First class side	30	0	0	20	0	0
8	end				13	0	0
9	Second class side	18	0	0	20	0	0
10	end				13	0	0
11	Third class side	12	0	0	13	0	0
12	end				10	0	0
	Door of carriage slightly damaged—						
13	First class side	10	0	0	8	0	0
14	end				5	0	0
15	Second class side	8	0	0	8	0	0
16	end				5	0	0
17	Third class side ..	6	0	0	5	0	0
18	,, end				4	0	0
19	Door of lavatory seriously damaged	12	0	0	8	0	0
20	,, slightly damaged	5	0	0	3	0	0
	Door fittings—						
21	Cap for door handle				0	4	0
22	Catch for sliding door brass ..				1	0	0
23	Door stop leather	0	8	0	0	4	0
24	Door stop leather with staple brass				0	12	0
25	Escutcheon for door lock brass				0	8	0
26	Handle for carriage door brass	2	0	0	[illegible]	0	0
27	with lock and plate ..	..			3	0	0
28	Hinge for carriage door brass top and middle	1	8	0	1	0	0
29	,, ,, bottom for turn under body	...	...	...	3	8	0
30	Hooks and eyes brass long	1	0	0	1	0	0
31	,, ,, short	0	8	0	0	8	0
32	Latch for lavatory door	1	0	0	1	0	0
33	Latch handle and plate for ditto	2	0	0	2	0	0
34	Nut door handle	...	...	...	0	4	0

APPENDIX F.

.... RAILWAY.

No. ....

Returns of vehicles cut off trains as unfit to run or re-issued to Traffic as fit to run.

.... 189 .

The Station Master .... *Station.*

Please note the following vehicles ....

.... *are now* .... *unfit* / *fit* .... *for use.*

No.	Description	Owning Company.	REMARKS.

Carriage Examiner.

APPENDIX G

Schedule of charges for damages to vehicles by passengers or troops while travelling by railway

Item	Description	Rates for 5 ft 6 in. gauge			Rates for metre gauge		
	PASSENGER VEHICLES	Rs.	A	P	Rs	A	P
	Door of carriage destroyed—						
1	First class side	45	0	0	30	0	0
2	„ end	...			20	0	0
3	Second class side	30	0	0	30	0	0
4	end				20	0	0
5	Third class side	18	0	0	20	0	0
6	end				15	0	0
	Door of carriage seriously damaged—						
7	First class side	30	0	0	20	0	0
8	„ end				13	0	0
9	Second class side	18	0	0	20	0	0
10	end				13	0	0
11	Third class side	12	0	0	13	0	0
12	end				10	0	0
	Door of carriage slightly damaged—						
13	First class side	10	0	0	8	0	0
14	end				5	0	0
15	Second class side	8	0	0	8	0	0
16	end				5	0	0
17	Third class side	6	0	0	5	0	0
18	end				4	0	0
19	Door of lavatory seriously damaged	12	0	0	8	0	0
20	slightly damaged	5	0	0	3	0	0
	Door fittings—						
21	Cap for door handle				0	4	0
22	Catch for sliding door brass				1	0	0
23	Door stop leather	0	8	0	0	4	0
24	Door stop leather with staple brass				0	12	0
25	Escutcheon for door lock brass				0	8	0
26	Handle for carriage door brass	2	0	0	2	0	0
27	with lock and plate ..				3	0	0
28	Hinge for carriage door brass top and middle	1	8	0	1	0	0
29	„ bottom for turn under body	..	..	...	3	8	0
30	Hooks and eyes brass long ..	1	0	0	1	0	0
31	„ short	0	8	0	0	8	0
32	Latch for lavatory door	1	0	0	1	0	0
33	Latch handle and plate for ditto	2	0	0	2	0	0
34	Nut door handle	...	...	...	0	4	0

APPENDIX G—*contd*

Item	Description		Rates for 5 ft 6 in gauge			Rates for metre gauge		
			Rs	A	P	Rs	A	P
	Lamps and fittings for oil—							
35	Lamp glass broken		2	8	0	2	0	0
36	" screen damaged		1	0	0	"		"
37	" ring or rod		0	8	0	0	8	0
38	" catch		0	8	0	0	8	0
39	Lamp reflector damaged	From	2	0	0	2	0	0
		To	4	0	0	4	0	0
40	Lamp shade damaged		3	0	0	1	0	0
	Lamps and fittings for gas—							
41	By pass or regulator handle		4	0	0	4	0	0
42	Globe broken		3	0	0	3	0	0
43	Pendant		5	0	0	5	0	0
44	Shade		1	0	0	1	0	0
	Lavatory fittings—							
45	Chain and plug for wash hand basin		1	0	0	0	8	0
46	Cock water brass broken		3	0	0	2	8	0
47	Commode cover		1	0	0	1	0	0
48	Coupling for lead pipe					1	0	0
49	Looking glass broken		10	0	0	10	0	0
50	Pipe for water supply lead per foot		1	0	0	1	0	0
5[illegible]	Washhand basin glazed earthenware		22	0	0	20	0	0
	Seats and Cushions—							
52	Cane back damaged		2	8	0	2	0	0
53	Cushion one destroyed 1st class		50	0	0	50	0	0
54	" " 2nd "		30	0	0	30	0	0
55	" torn	From	5	0	0	5	0	0
		To	15	0	0	15	0	0
	Top bed fittings—							
56	Bed rest bracket of ambulance		1	8	0	1	0	0
57	" hanging chain		1	0	0	1	0	0
58	" hanging hook		0	8	0	0	4	0
59	*Spring rest brass for top bed*					2	8	0
60	Stop bracket		1	0	0	1	0	0
61	Strap with buckle		0	9	0	1	0	0
	Miscellaneous fittings—							
62	Bolts brass		1	0	0	0	12	0
63	Bracket and lifting table		6	0	0	5	0	0
64	Finger lift of shutter or venetian brass		0	8	0	0	4	0

APPENDIX G—*concld*

Item	Description	Rates for 5 ft 6 in. gauge.			Rates for metre gauge		
		Rs	A	P	Rs	A	P
65	Hat peg brass ...	1	0	0	1	0	0
66	Hinge butt ordinary	0	8	0	0	8	0
67	Net, hat rack, destroyed ..	5	0	0	3	0	0
68	„ „ „ bracket, broken	2	8	0	2	0	0
69	Panel, wooden, broken ..	3	0	0	2	0	0
70	„ iron, small, damaged	1	0	0	1	8	0
71	„ „ large „	5	0	0	5	0	0
72	Pillow, leather, lost	12	0	0	8	0	0
73	„ „ damaged	5	0	0	2	8	0
74	Shutter damaged ..	4	0	0	2	0	0
75	„ of upper window	3	0	0	2	0	0
76	Socket for net rod				0	6	0
77	Studs for window straps				0	4	0
78	Top lights, small, in 2nd class	3	0	0	1	0	0
79	Venetian or shutter bar broken	0	8	0	0	8	0
80	„ „ frame	3	8	0	3	0	0
81	Window glass plain for 1st and 2nd	6	0	0	5	0	0
82	„ „ ground, for „	6	0	0	5	0	0
83	„ „ tinted for „	6	0	0	6	0	0
84	„ „ plain, for 3rd class	5	0	0	3	0	0
85	„ strap leather, long	3	0	0	2	0	0
86	„ „ „ short	1	0	0	1	0	0
87	„ lift leather	1	0	0	0	4	0
	Other Vehicles—						
88	Breast bars in covered goods	5	0	0	3	0	0
89	Door sunshade canvas	2	0	0			
90	Flap door board, covered goods	5	0	0	2	8	0
91	Horse box end panel ..	8	0	0	6	0	0
92	„ padding damaged	5	0	0			
93	„ „ „ From				3	0	0
	To				10	0	0
94	„ side shutters ...	3	0	0	2	8	0
95	„ stall post	8	0	0	4	0	0
96	Label boards lost	3	0	0	2	0	0
97	Partition boards in trucks	2	8	0	2	0	0
98	Padlock and key	2	0	0	2	0	0
99	Troughs in cattle trucks ...	6	0	0	4	0	0

APPENDIX H

Schedule of rates for repairs to stock belonging to foreign lines

Item	Description		Rates for 5 ft. 6 in. gauge			Rates for metre gauge		
			Rs	A	P	Rs	A	P
1	Axle boxes steel, complete with fittings	each				20	0	0
2	" without fittings	"				15	0	0
3	" C I complete with fittings	"	9	0	0	9	0	0
4	" without fittings		5	0	0	6	0	0
5	Bearing springs wagon	"	20	0	0	9	0	0
6	carriage ...	"	30	0	0	18	0	0
7	Buffer springs laminated "	"	30	0	0	6	0	0
8	Buffer and draw springs volute	"	6	0	0	5	0	0
9	Buffer plungers .	"	16	0	0	4	0	0
10	Buffer cases		12	0	0	5	0	0
11	Wheels and axles	per pair	230	0	0	140	0	0
12	Brass work	per cwt	125	0	0	120	0	0
13	Wrought iron work	"	25	0	0	25	0	0
14	Cast iron work	"	10	0	0	9	0	0
15	Door, First class side ...	each	45	0	0	30	0	0
16	" end	"				20	0	0
17	Door Second class side	"	30	0	0	30	0	0
18	" end					20	0	0
19	Door, Third class side	"	18	0	0	20	0	0
20	end	"				15	0	0
21	Door covered good ordinary	"	27	0	0	-		
22	" per set one side	"				40	0	0
23	Glass, common .	per sq ft	1	8	0	1	8	0
24	Glass tinted, window for 1st and 2nd ...	each	7	8	0	6	0	0
25	Glass white, window, for 1st and 2nd		6	8	0	5	0	0
26	" " for 3rd class		5	0	0	3	0	0
27	Venetian shutter for doors ...					4	0	0
28	Shutters wood					3	0	0
29	Timber teak including labour per cubic foot		6	0	0	5	0	0
	Credits to be allowed							
30	Brass scrap ...	per cwt	40	0	0	Current book rates of line retaining the material		
31	Cast iron scrap	"	1	4	0			
32	Steel scrap . .	"	2	8	0			
33	Wrought iron scrap		2	8	0			

SUBJECT No 15

The preparation of approved designs for Railway Workshops for different lengths of railway or conditions of traffic, showing in each case the leading dimensions and general arrangement recommended, with lists of machine tools required, and other information

References

Resolution adopted at Lahore (*Vol IV page 51, and Vol V, page 63*)

Note by Mr C E Crighton on South Indian Railway workshops at Negapatam (*Vol V, page 129*)

Mr C P Whitcombe submitted a note on the Southern Mahratta Railway workshops at Hubli, with list of tools and plant therein (*see page 198 in this Volume*)

Mr C E Crighton submitted a note on the South Indian Railway shops with list of tools and plant therein (*see page 215*)

The Sub Committee for the metre gauge submitted the following report —

1 It may be as well in the first place, to record the difficulty there is in deciding what is most suitable to recommend for Locomotive and Carriage and Wagon workshops, as designs suitable for one locality might be altogether unsuitable elsewhere

2 Economy both in first cost and in the current expenditure in the workshops afterwards depends to a large extent on the proper arrangement of the buildings and machinery at the commencement

3 In arranging our block plan we therefore assume that the site selected is on level ground, and for convenience we recommend that a standard size and form of roof for all buildings should be adopted Roofing made in spans of 42 feet is suitable for metre gauge workshops, so that any number may be combined for any site, and therefore the plan for the workshops is laid out in spans of 42 feet and the buildings can be added to at any time when necessary for the extension of the line The roof principals for such spans can be easily manufactured in this country from secondhand 40 lbs rails of 24 feet lengths

4 In designing workshops for a small railway the methods which obtain in larger shops should not be imitated, as special tools which may be applicable in the one case and which involve considerable outlay at the commencement, will be quite out of place in the smaller one Thus while in a small workshop the same wheel lathes may serve for the very different work of turning large driving wheels and small wagon wheels in a large workshop separate lathes are set apart for each of these duties

5 The block plan herewith submitted has been designed for workshops to hold 10 engines undergoing repair at one time, and for the construction and repairs being under taken of 100 coaching and goods vehicles, ample room being also provided in each case for largely increasing the accommodation

Workshops — Subject 15 — Both gauges.

6. If the General Committee approve of the design for a workshop to accommodate 10 engines at one time, the Sub Committee will submit recommendations as to details of equipment

7 The design submitted of the South Indian Railway erecting shop at Negapatam is recommended as an approved design for a building of this description We also submit plans of the Southern Mahratta Railway workshops at Hubli, and of the South Indian Railway at Negapatam, together with lists of machinery employed in these shops and descriptions of them by Mr Whitcombe and Mr. Crighton respectively

C. E CARDEW.
C. E CRIGHTON *(Representative).*
C P WHITCOMBE.

NEGAPATAM,
24th October 1894.

A letter was read from Mr L E H Brock, the representative of the Sub Committee for the 5 ft 6 in gauge, enclosing plans of certain existing railway workshops, and asking for further instructions from the General Committee on certain points

Resolution adopted.

1. That the block plan of workshops proposed by the Sub-Committee for the metre gauge be accepted as an "Approved Design" (*see plate XLV in this Volume*)

2 That the section of the South Indian Railway erecting shop be published for information (*see plate XLVI in this Volume*)

3. That the descriptions and drawings of the workshops of the South Indian and Southern Mahratta railways be published in part III (*see pages 198 and 215 in this Volume*), and that the Sub-Committee add a note pointing out any features in these arrangements which they consider either specially good, or in any way objectionable

4 With regard to Mr Brock's letter, the Committee point out that the questions raised in this are the very ones on which they desire that a recommendation should be made to them, after full consideration, by the members of the Sub-Committee, and refer the matter back to them for further consideration

SUBJECT No 16

Station machinery, including all apparatus used for watering, fuelling and turning engines, repairing, cleaning, and examining running Locomotive and Carriage and Wagon stock, loading, unloading and weighing goods, shunting or transferring stock from one line to another, and starting, stopping or signalling trains.

A.—STANDARD DIMENSIONS FOR LOADING GAUGE.

Metre gauge

It was pointed out that as the height at sides for metre gauge vehicles had been increased from 10 ft 0 in to 10 ft 2 in by Government of India, P W. D, circular No 10 Railway of 18th October 1894 (*see page 43*) that the loading gauge should be increased accordingly from 10 ft 1 in to 10 ft 3 in.

B.—CARRIAGE EXAMINING PITS

Attention was drawn to the resolution adopted at Madras (*Vol V, page 64*) and the resolution adopted at this meeting under subject 11 (*page 85 in this Volume*)

Resolution Adopted.

The Committee believe that Railway Administrations who have declined to provide proper examining pits are not aware of the serious responsibility which they thereby incur.

D —WASHING-OUT APPARATUS

The correspondence printed on page 223 in this Volume was read In Mr Cardew s letter, he did not point out, as was explained at the meeting that, as a general rule the locomotive officer on open line does not suffer any inconvenience from the fact that these defects exist in the type supplied to new works because when he requires new wash-out apparatus he specifies the type of hydrant he wants and generally makes the nozzles in his own shops It is when he takes over a new length of open line from the construction department, that he finds the running sheds fitted by that department with this apparatus, the pipes leading to the hydrants generally leak and can only be got at by pulling up the floor, the hose couplings and nozzles have, in many cases, a different pitch of screw from those already in use, and frequently have to be scrapped and new ones made, which entails a waste of time and money

Resolution adopted

1 That the defects brought to notice by Mr Cardew in the old standard washing-out apparatus, which is still supplied to State Railways under construction, are serious ones, and have been recognised as such for many years past

2 His proposals for remedying them appear to be well adapted for attaining that object. It is, however, considered that the pan type of apparatus is now no longer required, as leather hose has been superseded by canvas or rubber, and a stand pipe is preferable to a pan

3 It is therefore desirable that a drawing for a stand pipe for this purpose should be adopted as a standard, and the Sub Committees for workshops and station machinery are requested to collect opinions and drawings from Locomotive Superintendents, and select a standard for future use in all cases The selected drawing to be forwarded to the Secretary for submission to the Consulting Engineer for State Railways

SUBJECT No. 17.

General subjects not included in any of the preceding ones

A—THE FAILURE OF AXLES—IRON *versus* STEEL.

Material for axles.

Reference

Resolution adopted at Madras (*Vol. V, page 66*)

The last paragraph of Sir A. Rendel's report of 3rd July 1894, circulated with the Secretary's letter No C-99, dated 27th September 1894, was read —

"I would note in respect to paragraphs 3 and 9 (*of the Ajmere resolution, Vol. III, pages 46 and 48*) that we are now ordering, exclusively, steel for our axles, and that the breaking stress of the steel we use is fully one-third greater than that of the iron (Yorkshire) we used to send"

B —BREAKDOWN OR ACCIDENT RELIEF TRAINS

Reference

Resolution adopted at Madras (*Vol V page 66*)

The Sub Committee submitted a set of rules and a list of tools also a précis of opinions on the same from Locomotive Superintendents and Chief Engineers

Mr J E Berkley, member of the Sub Committee, suggested that the best way to obtain progress is that the present list be sent to the Secretary as a comprehensive list for breakdown or accident trains, and that it be optional for Locomotive Superintendents to adopt or modify the same

Mr C P Whitcombe member of the Sub Committee replied as follows —I think the best plan to adopt with regard to the breakdown train papers is to submit them in the form of a memorandum to the General Committee for discussion at next meeting We shall then see if there is any probability of general agreement My own view is that the class C train *will have to be cut out and the description of classes A and B modified* 15 ton cranes are not required for metre gauge railways 10 tons being ample, and jacks heavier than 10 tons are not wanted, but I have not gone into the matter with the other metre gauge members and on that account partly I recommend the submission of a memorandum for discussion by the General Committee instead of a report by the Sub Committee which could not be regarded as embodying the views expressed by the representatives of all railways The list of tools, etc, is I think, fairly complete but, as you remark some men *will want a few additions and others will prefer to leave some out*

Resolution adopted

1 That it is not necessary or desirable to have any permanent way material or engineers' tools beyond those specified under Miscellaneous Stores ' in the breakdown train Anything required beyond these can be collected and brought to site by the Engineering Department

2 That on the metre gauge only one class of train is necessary, consisting of—

1 10 ton crane

1 dummy which will also carry jacking pieces, etc

1 relief van fitted with brake to carry tools etc

3 That with this exception the following report and list of tools etc, be accepted and published for information only, it is not possible to draw up one list suited to the varying requirements on all railways the list therefore includes far more articles than are likely to be necessary in any one train It is believed that a complete list like this will prove a useful guide and prevent any article which is likely to be required being overlooked

Breakdown or accident relief trains for dealing with damages to rolling-stock

Note —Two classes of relief trains, A and B, appear to be necessary for dealing with damages to locomotive or carriage rolling stock These should be under the charge of the Locomotive or Carriage Superintendent and should generally consist of and be maintained as follows —

Class A Train

1 15 ton crane for 5 feet 6 inch gauge, or 10 ton for metre gauge, with dummy truck,

1 covered goods wagon,

1 open wagon, and

1 carriage of special design for accommodation of the breakdown gang

The crane should be built to lift 15 tons on 5 feet 6 inch gauge, or 10 tons on metre gauge, and fitted with a curved jib to give as great a headway as possible, the jib being lowered down on to a dummy truck for running The dummy truck might be so arranged as to allow of its carrying some of the packing or other breakdown gear

The covered goods wagon should be fitted inside with lockers and racks for holding tools and fittings and supplied with a brake that could be worked when necessary from the inside of the van, so that it might, if required, be run at the tail of the train and be used as a brake van

The open wagon should be loaded with packing and other heavy material

The carriage, the design of which would be approved hereafter should consist generally of a compartment at one end fitted for the accommodation of the foreman or other person in charge of the party, a large saloon compartment in the middle with lockers to hold tools, etc, the tops of the lockers being arranged so as to form sleeping berths for the men, table in the centre a compartment at the other end opening into the main or centre compartment this compartment to be used as a kitchen and brake compartment and if necessary, a part of it to be screened off for a latrine This carriage should be fitted with a brake

Class B Train

1 covered goods van,

1 open wagon and possibly in some cases,

1 crane with dummy truck.

The covered goods wagon to be fitted up generally in the same manner as the covered goods in the class A train excepting that the lockers might be arranged to form beds, a rough table being also fitted in the middle

Generally if not always, an open goods wagon to hold packing and other heavy material, should also be included in class B trains and, in some cases it may be advisable to also include a crane, though as the class B trains would only be used in cases of minor accidents in which it generally occurs that, owing to other vehicles, some of which are

Breakdown or accident relief trains — Subject 17 B — Both gauges

derailed being in the way, it will probably not, in all cases be found possible to use a crane it is considered that jacks only would be found generally sufficient Probably if a crane is included it should be of the same capacity as the one in the class A train

Each railway should possess one or more class A trains located at headquarters or at the larger stations, a class B train being located at each of the more important locomotive stations The numbers of each kind of train and the distance from each other at which they should be posted will depend on local circumstances, amount of traffic on the railway, etc, etc

Each of these two trains should be equipped for dealing with accidents to rolling stock only, and, though a few platelayers tools might be included in the fittings, arrangements for dealing with damages to permanent way should be entirely independent and distinct

Breakdown or accident relief trains — Subject 17 B — Both gauges

Tools and Gear to be kept in Accident Relief Trains

NOTE.—*It is not intended that all the articles shown in this list should be included in any one train*

Name of article		Number or Quantity Required		Remarks
		Class A	Class B	
Tools—Carpenters				
Adzes carpenters	No	2	1	
Augers carpenters screw as follows —				
2 inches diameter		2	2	
1½ inch		2	2	
1¼		2	2	
1		2	2	
⅞		2	2	
¾		2	2	
⅝		2	2	
½		2	2	
⅜		2	2	
Axes American		3	2	
Brace and bits	set	1	1	
Chisels carpenters firmer as follows —				
1½ inch	No	2	2	
1		2	2	
¾		2	2	
½		2	2	
¼		2	2	
Gimlets screw of sizes		6	6	
Mallets		4	2	
Saws cross-cut 6 feet		1	1	
Saws hand half rip 30 in.		2	2	
Screw-drivers 24 inches long		2	1	
12		2	1	
9		2	1	

Breakdown or accident relief trains— Subject 17-B — Both gauges

Name of article		Number or quantity required: Class A	Number or quantity required: Class B.	Remarks
Tools—Fitters' and Carriage Examiners'.				
Baskets, carpenters' hand, for holding fitters' tools while in use	No	6	3	Useful for preventing tools being trampled into the ballast and lost
Bench with 2 vices, 6 inch jaw, complete ...	„	1	...	
Braces, ratchet, 12 inches, with boring standards and clamps	„	2	1	
Callipers, inside, to take 6 inch ...	„	1	1	
Do. outside, do 6 „ ..	„	1	1	
Chisels, chipping, flat, 1"	„	9	6	
Do do ¾"	„	9	6	
Do, cross cut	„	6	3	
Do, rod, small	„	3	2	
Do, do, large	„	3	2	
Do, set or boilermakers'	„	6	3	
Drifts, steel, of sizes	„	12	6	
Feeders, oil, hand, pint size	„	3	2	
Foot rule	„	2	1	
Gauges, wheel, steel	„	*1*	*1*	
Do do for axle-guards	„	1	1	
Grindstone with trough complete ..	„	1		
Hammers, copper or brass	„	2	1	
Do., lead	„	2	1	
Do, flogging	„	4	2	
Do, sledge	„	4	2	
Do, hand, fitters' . ..	„	12	6	
Handles, hammer, fitters', spare	„	6	3	
Do. do. sledge, do ...	„	3	3	
Do, file	„	12	6	
Hand spikes, wooden...	„	6	3	
Needles, packing, of sizes	„	3	.	
Pinch bars	„	6	3	
Polishing clamps for vices	pair	1	...	
Punches, centre	No.	2	...	
Do. pin, of sizes, steel	„	12	6	
Do. rod, do. do.	„	6	3	

Breakdown or accident relief trains — Subject 17 B — Both gauges

Name of article		Number or quantity required		Remarks
		Class A	Class B	
Tools—Fitters and Carriage Examiners—*contd*				
Saw, hack, for iron	No	1		
Shovels, platelayers		3	2	
Spanners, assorted, for nuts and bolts from ¼" up to 2" diameter		36	4	
Spanners, claw or box, of sizes		6		
Do monkey, double 18"		2		
Do do do 12"		2	2	
Do do do 8		2	2	
Tape, measuring		1		
Tommy bars		6	3	
Vices, hand		2		
Wedges, steel, assorted		12	6	
Tools—Smiths				
Anvils, smiths, 1½ cwt	No	1		
Chisels, blacksmith, and sets, assorted		6		
Forge, portable, with bellows or blower attached		1		
Hammers, sledge		3		
Tongs, of sizes		6		
Lifting Appliances				
Beams, timber 12 × 12 × 8"	No	2		
12 × 12 × 6"	"	6	"	
4 × 12" × 6" ...	"	12	6	
4 × 10 × 5" ...	"	12	6	
4 × 10" × 3" ...	"	12	12	
2 × 10" × 4	"	12	10	
× 10 × 3" ...	"	24	4	
2 × 8 × 2"	"	24	24	
Wedges, wooden 1 × 4 × 1½	"	24	12	

Breakdown or accident relief trains — Subject 17 B — Both gauges

Name of article		Number or quantity required — Class A	Class B	Remarks
Lifting Appliances—*contd*				
Blocks differential pulley, with chain complete (Weston's), 2 tons	No	1		
Blocks differential, pulley, with chain complete (Weston's) 1 ton	„	1	1	
Blocks double, galvanised iron for 4" rope	„	2		
Do treble do do	„	2		
Do snatch iron 6" diameter	„	1		
Crab, double purchase		1		
Jacks, traversing 20 ton hydraulic, with levers complete	„	2		
Do do. 15 ton screw, with bars complete	„	6	4	Lighter jacks for metre gauge
Do carriage lifting do	„	6	4	Lighter jacks for metre gauge
Ramps steel double	„	6	4	
Rope Manilla 4½"	coil	½		
Do do 4"	„	1	½	
Do do 2"	„	1	½	
Do or chain, tail, with hook at each end	No	2	1	
Lighting				
Lamps brake-van side	No	2	2	
Do. do. tail	„	2	2	
Do hand or lanterns		12	6	
Do. do. signal tricolour		2	2	
Match safety boxes		6	3	
Torches old rope		5	5	
Wells lighting apparatus with reservoir and fittings complete		1	—	
Wells patent gas lamps with stands and boxes	„	6	4	
Wicks lamp, assorted to suit lamps above	bundle	1	1	

Breakdown or accident relief trains — Subject 17-B — Both gauges

Name of article		Number or quantity required: Class A	Number or quantity required: Class B	Remarks.
Cooking Utensils, etc				
Basins, washhand, metal	No	2		
Buckets, iron, galvanised	„	6	3	
Chatties or pots, earthen	„	12	6	Stowed in frame under wagon and filled with drinking water
Coffee pot, tin	„	1	1	
Cooking pots, earthenware assorted	„	12	6	
Frying pans	„	2	1	
Forks, spoons and knives, each	„	*6*	*6*	
Kettles iron	„	2	1	
Mussucks	„	1		
Tin mugs	„	12	6	
Do plates	„	12	6	
Towels	„	6	3	
Miscellaneous Stores and Tools				
Axle-boxes with brasses	No	4	2	
Bars, iron, wrought—				
1¼" dia. × 4' long	„	2		
1" „ × 6'	„	2		
⅞" „ × 6	„	2		
¾" „ × 10'	„	2		
⅝" „ × 10'	„	2	...	
½" „ × 10'	„	2	...	
Baskets, cooly, cane or bamboo	„	12	6	
Beaters platelayers', with handles	„	2	1	
Bolts, of sizes, assorted	„	100	50	
Box with telegram forms general rules working time-table, paper, envelopes ink, etc.	„	1	1	
Brooms country	bundle	1	...	
Buffers with springs and bolts	No.	4	2	
Chain, iron, 1"	ft.	30	10	
Do. do. ¾"	„	30	20	
Do. do. ½"	„	10	20	

Breakdown or accident relief trains — Subject 17-B — Both gauges.

Name of article.		Number or quantity required.		Remarks.
		Class A.	Class B.	
Miscellaneous Stores and Tools—*contd.*				
Chain, Shooks, of sizes	No.	6	6	
Couplings, screw	"	4	2	
Files, assorted	"	24	12	
Flags, signal, with staves	"	6	4	
Gauges, rail	"	2	1	
Glasses, gauge, spare	"	3	...	
Hammers, keying	"	2	1	
Lead, red	lbs.	28	28	
Do., white, moist	"	28	28	
Medical appliances in chests (see list for contents) ...	No.	1	1	
Nails, assorted	lbs.	10	10	
Nuts, of sizes, assorted	No.	50	50	
Oil, cocoanut	gals.	5	2	
Do., castor	"	5	2	
Do, kerosine	tins	3	2	
Do, linseed	gals.	1	½	
Screws, wood, assorted	gross	5	2	
Do., coach, assorted	"	50	50	
Shackles, coupling, with pins and washers ...	No.	4	2	
Do., spring or harness	sets	4	2	
Signals, fog, in tin cases of 12	No.	24	12	
Soap, soft	lbs.	5	...	
Do., yellow, washing, bar	No.	1	1	
Spring clips or plates with bolts, of sizes ...	"	6	3	
Split pins, assorted	gross	1	½	
Tallow	lbs.	10	5	
Twine, assorted	balls	3	2	
Waste, cotton	lbs.	56	56	
Washers, iron, assorted	No.	200	100	
Wire, trimming	rolls	1	1	
Worsted, do.	bundles	1	1	

Breakdown or accident relief trains — Subject 17-B — Both gauges.

Name of article.		Number or quantity required.		Remarks.
		Class A.	Class B.	
Miscellaneous Stores and Tools—*contd.*				
Chain, Shooks, of sizes	No.	6	6	
Couplings, screw	"	4	2	
Files, assorted	"	24	12	
Flags, signal, with staves	"	6	4	
Gauges, rail	"	2	1	
Glasses, gauge, spare	"	3	...	
Hammers, keying	"	2	1	
Lead, red	lbs.	28	28	
Do., white, moist	"	28	28	
Medical appliances in chests (see list for contents) ...	No.	1	1	
Nails, assorted	lbs.	10	10	
Nuts, of sizes, assorted	No.	50	50	
Oil, cocoanut	gals.	5	2	
Do., castor	"	5	2	
Do., kerosine	tins	3	2	
Do., linseed	gals.	1	½	
Screws, wood, assorted	gross	5	2	
Do., coach, assorted	"	50	50	
Shackles, coupling, with pins and washers ..	No.	4	2	
Do., spring or harness	sets	4	2	
Signals, fog, in tin cases of 12	No.	24	12	
Soap, soft	lbs.	5	...	
Do., yellow, washing, bar	No.	1	1	
Spring clips or plates with bolts, of sizes ...	"	6	3	
Split pins, assorted	gross	1	½	
Tallow	lbs.	10	5	
Twine, assorted	balls	3	2	
Waste, cotton	lbs.	56	56	
Washers, iron, assorted	No.	200	100	
Wire, trimming	rolls	1	1	
Worsted, do.	bundles	1	1	

Breakdown or accident relief trains — Subject 17 B — Both gauges

Contents of medicine chests for Railway Accident Relief Vans

(List drawn up by the Surgeon General with the Government of India and published with Director General of Railways Circular No 1, dated 1st May 1893)

Box No 1.

Centre Compartment

Under tin tray

Gauze antiseptic	3 yds.
Do spare	6 "
Pestle and mortar Wedgewood 4 ozs	1
Scales and weights grains	1
**Sponge antiseptic*	6
Do fine	1 lb
Syringe brass ear	1
Do hypodermic	1
Tourniquets field	6
Do screw	4

Right Compartment

Acid boric	8 ozs
Do carbolic pure	1 lb.
Antiseptic solution in 2 bottles	2
Aromatic spirits of ammonia	8 ozs
Batley's Sedative (liquor opii sedativus)	4
Chloroform	1 lb.
Solution of ammonia	8 ozs.
Spirits of ether	4
Sulphate of quinine in 2-grain pills	200 No.
Tincture of opium	8 ozs.
Tincture of perchloride of iron	6 "
Bandages antiseptic, open wove	24 ozs
Bandages calico, triangular Esmarch's	1 doz.
Ligature flax	3 ozs.
Artery forceps, Spencer Wells	6 "

Left Compartment.

Alum to purify local water-supply	1 lb.
Carbonate of ammonia	4 ozs.
**Carron oil*	4 lbs
Compound tincture of Benzoin	1 lb.
†*Ergotine Bonjeau's prepared for hypodermic injection*	*1 dr*
Hydrate of chloral	4 ozs.
Iodoform	1 oz
Morphia hypodermic B P injection of	1
Ointment of boric acid	1 lb
Opium in 1 grain pills	150 No.
Collodium	4 ozs.
Brand's essence of mutton	12 tins.
Carbolised catgut	1 bot.
Clasp knife	1
Corkscrew	1
Dredger tin for iodoform	1
Inhalers conical cloth for chloroform	2
Measure glass minim	1
Do. 1 oz	1
Pins paper	1
Do. safety	1 pkt.
Plaster adhesive 1 inch tape English	3 yards or 1 tin.
Scissors shop	1
Silk antiseptic protective	1 yd
Silk ligature	3 ozs.
Stethescope	1
Tubing drainage	1 yd

In Drawer

Bandages of sizes	12 No.
Cloth sheeting	4 yds
Lint, boric	4 "
Do. carbolised	2 lbs.
Tow antiseptic	4 "
Unbleached longcloth	6 yds.
Wool, absorbent	6 lbs.

* Not on the stock list of the Medical Stores Department—to be prepared locally

† " " " —to be purchased locally

Breakdown or accident relief trains — Subject 17-B. — Both gauges.

Box No. 2.

Brandy ...	4 bots		In Drawer.		
Basins, metal, dressing	3		*Splints, arm	14	
Iodoform, wool	8 ozs		Do. common	23	
Plaster, resin, spread	15 yds		Do. leg, 4 pairs	2 sets.	
Carbolised cotton	2 lbs		Do long, inclined	1	
Antiseptic gauze, 6 yds pieces	4		Do rattan	2 sets.	
* *Soap, carbolic*	*1 cake*		Do. thigh	8 pairs.	
Sponges	2 lbs				
Absorbent cotton	1 lb.				

* Not on the stock list of the Medical Stores Department—to be purchased locally

NOTE.—The distribution of these medicines and medical requirements appears to admit of some revision, and it is thought a better and more convenient arrangement would be to have one box, about 2′ 6″ × 1′ 6″ × 1′ 6″ or 1′ 8″ deep, divided mainly into two compartments, one compartment being fitted with trays to lift out or slide, in which should be stowed all small bottles of medicine, instruments, bandages and other light things, the more bulky articles going into the other compartment.

A second box, about 1′ 6″ × 5′ 0″ × about 1′ 0″ deep, would carry the long splints, bottles of brandy, washing basins and other heavy or bulky articles

The following additions should, it is considered, be made to the Surgeon General's list.—

Surgeon's pocket case No 1.
Major operation do „ 1.
Morphia acitatis in ¼-grain pills—No 100
Concentrated solution, perchloride of mercury, oz 4.
Catheters, gum elastic, set 1
Brass syringe, clyster, No. 1.
Kerosine-oil, quart 1.
Bleached longcloth, yards 6
Splints, rectangular, sets 2.

The arrangements of each of these chests might be left to the medical officers of the different railways, the Surgeon General's list and the above note being adopted, if approved, for general guidance and information, each railway being left free, so long as the general principle is not departed from, to add to or omit from the list such details as may be thought advisable

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

PART III.—NOTES AND CORRESPONDENCE.

CALCUTTA—DECEMBER 1894.

NOTICE.

The Committee as a body is not responsible for the opinions expressed in Part III of the Proceedings

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

NOTES AND CORRESPONDENCE, 1894.

APPROVED DESIGNS OF LOCOMOTIVES — SUBJECT 1

OFFICIAL CORRESPONDENCE.

Copy of a letter from the Director General of Railways, No 228-S, dated 4th March 1895, to the Secretary to the Committee of Locomotive and Carriage Superintendents.

The undermentioned papers are forwarded to the Secretary to the Committee of Locomotive and Carriage Superintendents, for information with reference to the correspondence ending with his No D 89 A, dated 3rd November 1894 * It is suggested that serious consideration may be given to the remarks made by the Consulting Engineer at the India Office in his report dated 2nd November 1894

Copy of letter No S 11371, dated London, 5th November 1894, from the Director General of Stores to the Director General of Railways together with copy of report by the Consulting Engineer at the India Office, dated 2nd November 1894

I have the honour to enclose for your information copy of a report, dated 2nd November 1894, by the Consulting Engineer with reference to the diagrams of locomotive engines which accompanied your letter No 1601 S of 8th October 1894

Copy of report by the Consulting Engineer, dated 2nd November 1894

I have retained the diagrams of locomotive engines forwarded by the Director General of State Railways and which he states have been accepted by the Committee of Locomotive and Carriage Superintendents as approved designs I presume the Director General of Railways is satisfied with the designs himself as he forwards them without comment for my use.

It appears to me that the great object of the Committee of Locomotive and Carriage Superintendents should be to establish standard designs of locomotives, carriages and wagons, based on their combined experience as being best suited to the varying circumstances of each Railway.

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* F[illegible] diagrams of approved Designs.

Locomotives—Approved Designs—Subject 1

But this is a result not yet arrived at Taking the locomotives ordered since this Committee was formed, six broad gauge railways have indented for passenger engines. All differ from each other, and only one is for a type in use The rest are additional types designed in India Four lines have indented for goods engines, three of them for new types designed in India, and I understand a fifth new Indian design of engine will *shortly be indented for*

Thus it appears that the Locomotive Superintendents of India concur in one thing only, and that is that what the Consulting Engineers to the Secretary of State and to the Companies send out to them is more or less wrong I submit that this is only to make matters worse unless they can agree on what is right, because the differences of opinion are increased instead of being diminished, and the number of types increases with the number of opinions

I am quite aware that the same thing happens on English railways Every change of management here introduces a fresh crop of designs, with the result that standard types of engines are practically unknown in England, and needless expense is incurred I think steps should be taken to prevent this going on continuously in India

In my opinion the time has arrived when any demand for a new type of engine should be accompanied by a report justifying the passing by of existing types

In respect to the weight of the engines shewn on the diagrams you send me, in four *cases they are mere estimates*, and are quite different from the actual weights which the designers in India invariably understate, and very largely so in some cases

For instance the weight of the new East Indian Railway passenger engines is given as 44.5 tons whereas the actual weight of the lightest of them is 48.38 tons, and is over the Government maximum The Bombay, Baroda and Central India Railway passenger compound, not yet let to contract is said to weigh 45.75 tons with a maximum load of 14.5 tons on one axle If this engine is built to the detail and general drawings, sent me the load on the driving axle will certainly exceed 16 tons and the total weight will closely approach that of the *East Indian engine*

Again in the case of the Bombay Baroda and Central India Railway compound goods engine the weight given in the diagrams largely exceeded the Indian estimate It also exceeds the Government limit yet the design is placed among the approved types without comment *

I would therefore suggest that in future any design for either a new type of engine or one so different from the type on which it is founded as to seriously affect the weight of the engine should be accompanied by an estimate giving at least every important part in detail so that we may not have in future the mistakes on this point we have had in the past The desire to obtain power always makes a Locomotive Superintendent over-sanguine on the question of weight

Are engines which are not shewn on the diagrams to be sent out? I ask because the B N R and the East Coast Railway have both indented for engines, the former for passenger engines and the latter for both goods and passenger engines, none of which are among the designs shewn on the diagrams

In the case of the metre gauge lines, I note with pleasure, as having been responsible for them, that the two existing types, the *O & I, have been accepted as standards*, as indeed they have been for many years past, and I am glad to see that the aim is to improve them and not to supersede them by new types

* Sir A Rendel's mistake, see Vol V, page 13

Locomotives—Approved Designs—Subject 1

Copy of a letter No 179 S, dated the 20th February 1895, from the Director General of Railways, to the Director General of Stores, India Office London

With reference to your letter No S 11371, dated the 5th November 1894 forwarding a *copy of a report, dated the 2nd November 1894, by the Consulting Engineer at the India* Office, with reference to the diagrams of locomotive engines accepted by the Committee of Locomotive and Carriage Superintendents in India as approved designs, I have the honour to forward for the information of the Consulting Engineer a copy of the marginally noted correspondence regarding the constitution of the Committee in India and the supply of copies of its proceedings etc, to the Consulting Engineer

Government of India letter No 107-R S dated the 18th July 1891
Government of India Memorandum No 272 R S dated the 1st August 1893 with extracts paragraph 2 and 3 of its enclosures

The rules referred to in Government of India letter No 107 R S, dated the 18th July 1891, will be found at pages 3—12 of the Proceedings of the Committee s Volumes I to V, a copy of which was sent you under my letter No 109 S, dated the 30th January 1895 The intentions of the Government of India in regard to the position of the Committee and the force of its resolutions have been more clearly defined in their letter No 115 R S dated the 22nd March 1894 a copy of which is also enclosed

2 It will be seen from the copy of the correspondence forwarded that the diagrams of engines were sent to the Consulting Engineer, in accordance with the instructions of the Government of India conveyed in their letter No 272-R S dated 1st August 1893 merely for information as to the views of the Committee of Locomotive and Carriage Superintendents and not as in any way representing either the views of the Director General of Railways or the orders of the Government of India

3 I would add that I agree generally with the remarks made by the Consulting Engineer, and that I am prepared to co-operate to the best of my authority in keeping down the number of types of locomotive engines in use on Indian railways to the lowest number compatible with the efficient service of their traffic, which is worked under very varied conditions

Locomotives—Approved Designs—Subject 1

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FUEL EQUIVALENTS — SUBJECT 3-E.

Trial of Burma Coal Company's Thingadaw Coal for efficiency with other Fuels

SCHEDULE I

Statement of actual consumption and cost of working with different Fuels on Toungoo Mandalay Line

Engines,—I S R, Class F Trains,—mixed Running speed,—18 miles per hour Weather,—dry and favourable

1					2					3				
Wood fuel. From 19th to 2 th March 1894 (Four engines in 11 days)					Bengal Coal Company's Karharbari coal. For October and November 1890 ([illegible]) (Twenty engines in 61 days)					Welsh patent fuel. From 1st to 11th March 1894 (Four engines in 11 days)				
Engine mileage	Ton-mileage	Consumption	Cost	Water total gal lons consumed	Engine mileage	Ton mileage	Consumption	Cost	Water total gal lons consumed	Engine mileage	Ton mileage	Consumption	Cost	Water total gal lons consumed
		lbs	Rs				lbs	Rs				lbs	Rs	
4 180	1 004 418	309 170	546	74 283	127 302	30 043 272*	3 57[illegible],800	30 528		4 180	1 011 [illegible]53	93 184	817	77 827

4					5					6				
Burma Coal Company's Anthracite coal. From 1st to 11th January 1894 (Four engines in 11 days)					Mr B[illegible] Company's Burma coal. From 5th to 15th February 1894 (Four engines in 11 days)					Burma Coal Company's Thingadaw coal. From 15th to 25th January 1894 (Four engines in 11 days)				
Engine mileage	Ton-mileage	Consumption	Cost	Water total gal lons consumed	Engine mileage	Ton mileage	Consumption	Cost	Water total gal lons consumed	Engine mileage	Ton mileage	Consumption	Cost	Water total gal lons consumed
		lbs	Rs				lbs	Rs				lbs	Rs	
4 180	9 6 557	126 8[illegible]6	936	78,[illegible]27	4 180	1 004 375	136 752	934	80 [illegible]55	4,180	9[illegible]6 013	205,072	1 138	80 006

* Ton mileage was not recorded in this trial of 1890 so it has been estimated at 236 tons per engine mile the average of 1894 trials, the same class of train and engines having been employed in both years

Cancelled

INSEIN,
2rd August 1894

C E CARDEW,
Locomotive Superintendent.

FUEL EQUIVALENTS — SUBJECT 3-E.

Trial of Burma Coal Company's Thingadaw Coal for efficiency with other Fuels.

SCHEDULE I.

Statement of actual consumption and cost of working with different Fuels on Toungoo-Mandalay Line.

Engines,—I. S. R., Class F Trains,—mixed. Running speed,—18 miles per hour. Weather,—dry and favourable.

1					2					3				
Wood fuel. From 10th to 29th March 1894. (Four engines in 11 days)					Bengal Coal Company's Karharbari coal For October and November 1890. (Used as standard) (Twenty engines in 61 days)					Welsh patent fuel From 1st to 11th March 1894. (Four engines in 11 days.)				
Engine-mileage.	Ton-mileage.*	Consumption.	Cost.	Water, total gallons consumed.	Engine-mileage.	Ton mileage.	Consumption.	Cost.	Water, total gallons consumed	Engine-mileage.	Ton mileage.	Consumption.	Cost.	Water, total gallons consumed.
		lbs	Rs				lbs	Rs				lbs	Rs	
4 180	1 004 418	376 320	665	74 283	127,302	30 043 272*	3 572,800	30 528	..	4 180	1,011,453	93,184	817	77,827

4					5					6				
Burma Coal Company's Anthracitic coal. From 1st to 11th January 1894. (Four engines in 11 days)					New Birbhum Company's Dorea coal. From 5th to 15th February 1894. (Four engines in 11 days.)					Burma Coal Company's Thingadaw coal. From 15th to 25th January 1894 (Four engines in 11 days)				
Engine-mileage.	Ton-mileage.	Consumption.	Cost.	Water, total gallons consumed.	Engine mileage.	Ton mileage.	Consumption.	Cost.	Water, total gallons consumed	Engine mileage.	Ton mileage.	Consumption.	Cost.	Water, total gallons consumed.
		lbs	Rs				lbs	Rs				lbs	Rs	
4,180	926 157	126 836	936	78 827	4 180	1 004 375	126,752	904	80,155	4,180	936 013	205,072	1,138	80,006

* Ton mileage was not recorded in the trial of 1890, so it has been estimated at 236 tons per engine mile, the average of 1894 trials, the same class of train and engines having been employed in both years.

INSEIN;
2nd August 1894.

C. E. CARDEW,
Locomotive Superintendent.

Locomotives — Fuel equivalents — Subject 3-E.

SCHEDULE II.

Analysis (from Schedule I) of comparative cost of working with different kinds of Fuel

1	2	3	4	5	6	7	8	9	10	11	12	13			14
Kinds of fuel.	Supply price delivered on line.* Per ton.	Trafage charges after delivery for carrying to depôt.† Per ton	Average cost of fuel on Toungoo-Mandalay line delivered at depot (columns 2 + 3) Per ton.	Consumption	Cost.	Relative consumption co-efficient (obtained by dividing figures in columns 5 (a) and 5 (b) by those for Karbarbari coal therein given)	Relative cost co-efficient (obtained by dividing figures in columns 6 (a) and 6 (b) by those for Karbarbari coal therein given)	Cost of different fuels to do same work as 1 ton of Karharbari coal (obtained by multiplying corresponding figures in column 4 by columns 7 (a) and 7 (b))	Various prices for Thingadaw coal to beat the other fuels (obtained by dividing figures in previous columns by figures for Thingadaw coal in columns 7 (a) and 7 (b) and subtracting 1.435 of column 3)	Pounds water evaporated per pound of fuel.	‡ Pounds water evaporated per 1,000 ton mile of load.	Percentage of ashes to fuel burnt. In smoke-box	In ash pan.	Total.	Unit of efficiency of consumption (pounds burnt per square foot of grate area per second).§
	Rs	Rs	Rs.	lbs	Rs	lbs	Rs	Rs.	Rs.	lbs	lbs.				
1. Wood fuel	3.625	0.333	3.958	(a) 90.03 (b) 375	0.159 0.662	3.207 3.151	0.662 0.652	12.603 12.472	5.826 5.343	1.974	740	0.34	4.36	4.70	0.029
2. Bengal Coal Company's Karharbari coal	15.625	3.524	19.149	(a) 28.07 (b) 119	0.240 1.016	1.000 1.000	1.000 1.000	19.149 19.149	9.520 8.972	..	..	..	...	...	...
3. Welsh patent fuel	17.175	3.524	20.649	(a) 22.29 (b) 92	0.195 0.808	0.794 0.773	0.812 0.795	16.395 15.962	7.944 7.240	8.352	769	1.07	16.52	17.59	0.007
4. Borea Coal Company's Anthracite coal	13.000	3.524	16.524	(a) 30.36 (b) 130	0.224 0.958	1.082 1.092	0.933 0.943	17.879 18.044	8.793 8.372	6.212	808	0.09	22.50	22.59	0.009
5. New Birbhum Company's Borea coal	12.750	3.524	16.274	(a) 32.72 (b) 136	0.238 0.990	1.166 1.143	0.992 0.974	18.975 18.601	9.420 8.674	5.861	799	0.17	29.98	30.15	0.010
6. Thingadaw	11.000	1.435	12.435	(a) 49.06 (b) 219	0.272 1.216	1.748 1.840	1.133 1.197	21.736 22.880	— —	3.901	855	0.21	31.78	31.99	0.016

(a) Per engine mile (b) Per 1,000 ton miles

* The prices of the various fuels are the latest paid, except that for Karharbari coal, of which none has been purchased since 1890, none having been offered on any tenders for contracts let.

† All fuel burnt in these trials has been assessed for carriage as if carried to Yamethin, which is the midway depôt of the district and, therefore, furnishes a true average.

‡ Ten pounds of water = 1 gallon

§ Air spaces between fire bars 1 inch for all fuel, except wood and patent fuel, which had ⅝ inch.

C. E. CARDEW,

Locomotive Superintendent.

INSEIN;

2nd August 1894.

Locomotives — Fuel equivalents — Subject 3-E

SCHEDULE II

Analysis (from Schedule I) of comparative cost of working with different kinds of Fuel

1	2	3	4	5	6	7	8	9	10	11	12	13			14
Kinds of fuel	Supply price delivered on line* Per ton	Trainage charges after delivery for carrying to depôt † Per ton	Average cost of fuel on Toungoo-Mandalay line delivered at depôt (columns 2 + 3) Per ton	Consumption	Cost	Relative consumption coefficient [obtained by dividing figures in columns 5 (a) and 5 (b) by those for Karharbari coal there given]	Relative cost coefficient [obtained by dividing figures in columns 6 (a) and 6 (b) by those for Karharbari coal there given]	Cost of different fuels to do same work as 1 ton of Karharbari coal [obtained by multiplying corresponding figures in columns 4 by columns 7 (a) and 7 (b)]	Various prices for Thingadaw coal to beat the other fuels [obtained by dividing figures in previous columns by figures for Thingadaw coal in columns 7 (a) and 7 (b) and subtracting 1 435 of column 3]	Pounds water evaporated per pound of fuel	‡ Pounds water evaporated per 1 000 ton mile of load	Percentage of ashes to fuel burnt: In smoke box	In ashpan	Total	Unit of efficiency of consumption (pounds burnt per square foot of grate area per second) §
	Rs	Rs	Rs.	lbs	Rs	lbs	Rs	Rs	Rs	lbs	lbs				
1 Wood fuel	3 625	0 333	3 958	(a) 73 95 (b) 308	0 131 0 544	2 634 2 588	0 546 0 535	10 425 10 243	4 529 4 132	2 403	740	0 34	4 36	4 70	0 024
2 Bengal Coal Company's Karharbari coal	15 625	3 524	19 149	(a) 28 07 (b) 119	0 240 1 016	1 000 1 000	1 000 1 000	19 149 19 149	9 520 8 972						
3 Welsh patent fuel	17 175	3 524	20 649	(a) 22 29 (b) 92	0 195 0 808	[illegible]794 0 7[illegible]	0 812 0 795	16 395 15 962	7 944 7 240	8 352	769	1·07	16 52	17 59	0 007
4 Borea Coal Company's Anthracite coal	13 000	3 524	16 524	(a) 30 36 (b) 130	0 224 0 958	1 082 1 092	0 [illegible]3 0 943	17 879 18 044	8 793 8 372	6 212	808	0 09	22 50	22 59	0 009
5 New Birbhum Company's Borea coal	12 750	3 524	16 274	(a) 32 72 (b) 136	0 238 0 990	1 166 1 143	0 992 0 974	18 975 18 601	9 420 8 674	5 861	799	0 17	29 98	30·15	0 010
6 Thingadaw	11·000	1 435	12 435	(a) 49 06 (b) 219	0 272 1 216	1 748 1 840	1 133 1 197	21 736 22 880	— —	3 901	855	0 21	31 78	31 99	0 016

Cancelled

(a) Per engine mile (b) Per 1 000 ton miles

* The prices of the various fuels are the latest paid, except that for Karharbari coal, of which none has been purchased since 1890, none having been offered on any tenders for contracts let

† All fuel burnt in these trials has been assessed for carriage as if carried to Yamethin, which is the midway depôt of the district and, therefore, furnishes a true average

‡ Ten pounds of water = 1 gallon

§ Air spaces between fire bars ⅜ inch for all fuel, except wood and patent fuel, which had ⅜ inch

INSEIN;

2nd August 1894

C. E CARDEW,

Locomotive Superintendent.

FUEL EQUIVALENTS — SUBJECT 3 E

Memorandum by Mr C E Phipps, Locomotive Superintendent, Madras Railway, dated Perambur, 22nd November 1894 on further experiments carried out with Kurhurbaree, Singareni and Borakur coals and with Star Patent fuel

Statement A shows the results of experiments conducted with these fuels on the mails and fast passenger trains between Madras Jalarpet and Madras-Cuddapah

Statement B shows the results of experiments on the mixed trains working between Madras Katpadi and Madras Renigunta.

The Kurhurbaree coal with which both sets of these experiments were conducted, was of most excellent quality and was perhaps the best sample of coal that has been used on this line for many years It was clean, free from slack and dirt, and in itself was all that could be desired, as it burnt freely and brightly, and engines using it steamed as well as the most captious engineman could have wished The Singareni coal was of the ordinary kind now being delivered by the contractor and the Borakur coal was part of a consignment delivered in March 1894 This was not, however, of very good quality, nor equal to coal of the same description that has been used on this line formerly The Patent fuel was an old stock, and although this fuel is, as a rule, practically unaffected by weather, it is probable it had to some extent deteriorated during the four years it had been in stock

Dealing first with series A these experiments were as is noticed above, made with the SC class engines on the mail and passenger trains and are therefore, similar to series B and C in the table accompanying my memorandum dated 15th January 1894, and printed at page 77 of volume V of proceedings of the Committee of Locomotive and Carriage Superintendents

The following shows the average comparative results in the three series of trials —

	Consumption per vehicle per mile				Fuel equivalent Kurhurbaree being assumed as unity			
	Kurhurbaree	Singareni	Borakur	Patent fuel	Kurhurbaree	Singareni	Borakur	Patent fuel
Series B—1890 } See page 77 of volume V		2·35	2·12		1·00	1·20	1·09	
C—1891 }		2·20	1·94	1·70	1·00	1·03	0·91	0·80
A—1894—now under reference	2·13	2·5	2·5[illegible]	2·20	1·00	1·20	1·18	1·03

It will be observed that with each fuel the consumption has been heavier per vehicle per mile in the recent experiments than in the trials conducted in 1890 and 1891, and I regret I am unable to account entirely for this difference Probably the windy weather which prevailed more or less throughout the trials may have had something to do with this, as in December, the month in which the 1890 and 1891 trials were conducted the weather in Southern India is generally calm and fine The 1890 trials were further conducted by two picked men, and the engines used were perhaps in rather better fettle than those working in May and June last which were not specially selected Some little difference may also be due so far as the Patent fuel is concerned to the fact that this fuel was fresher and in better order in 1891 than was the case in 1894

Locomotives — Fuel equivalents — Subject 3-E

The experiments, the results of which appear in statement B, were conducted with *the KB and KB_2 class engines working the mixed trains and were similar in conditions* to those shown as series D in the memorandum of the 15th January last referred to above

The comparative results are —

	CONSUMPTION PER VEHICLE PER MILE				FUEL EQUIVALENT, KURHURBAREE BEING TAKEN AS UNITY			
	Kurhur baree	Singa reni	Borakur	Patent fuel	Kurhur baree	Singa reni	Borakur	Patent fuel
Series D—1893—see page 77 of volume V		1 75	1 60	1 39	1 00	1 01	0 92	0 80
Series B—1894—now under reference	1 40	1 70	1 54	1 38	1 00	1 21	1 10	0 99

and it *is very remarkable how closely these figures, so far as the consumption per vehicle* per mile goes, agree with each other

A considerable difference is observed in the fuel equivalents resulting from the recent experiments as compared with those of the previous trials, and it is further noticeable that although the equivalents shown in the two series A and B, now under review, both give a lower value for each of the fuels tested as compared with Kurhurbaree than was obtained in the earlier trials, the equivalents in both, *viz*, series A and B are practically the same, and further the relative proportionate value of Singareni, Borakur and Patent fuel is as nearly as possible identical with the values given in the 1891 and 1893 trials

That is in the 1891 and 1893 trials in which Borakur and Singareni were tested against Patent fuel and the comparison with Kurhurbaree was made upon the basis of the equivalents fixed in the Government of India circular No 7, the figures are —

Patent fuel assumed value as fixed in circular No 7			...	80
Borakur, average of the series C and D			...	92
Singareni	do	do ..	..	1 02

and if the experiments now being considered are compared upon the same basis and Singareni and Borakur coal referred to Patent fuel with an assumed value of 80, the equivalents would be —

Patent fuel ...	... .	·80
Borakur coal		·91
Singareni		98

The close similarity appearing here would seem to show that the respective experiments may be considered to be reliable and to have established with sufficient accuracy the actual relative values of the fuels tested It would further seem to be proved that the value for Kurhurbaree coal fixed in Government of India circular No 7 of 19th June 1891, upon which the equivalents for the earlier experiments were calculated *is too low*, and that this coal or at any rate *the sample of it which we have recently tried*, is of even better quality than is assumed by the Government of India. No doubt, as I have mentioned, the fact that both the Borakur coal and Patent fuel now tried were in some way inferior as compared with the samples used in the last experiments, has affected the values to some extent, but, in view of the figures given above, I think it may be safely held that the Kurhurbaree coal is better than it was thought to be.

C. E. PHIPPS,

Locomotive Superintendent.

STATEMENT A.

Statement showing Results obtained in Experiments with Kurhurbaree, Singareni, and Borakur Coals and Patent Fuel burnt in Engines working Mail and Passenger Trains between Madras-Jalarpet and Madras-Cuddapah.

Kind of Fuel	Engine Class S C.* No	Date when the trials were made	Total miles run during the trial	Total time standing in steam during the trial	Average length of each trip	Average speed per hour	Average number of vehicles	Average weight of train including engine	Total consumption of fuel	Weight of Ashes removed: From Smoke box	Weight of Ashes removed: From Ash-pan	Weight of Ashes removed: Total	Consumption of fuel per train mile	Consumption of fuel per vehicle per mile	Consumption of fuel per mile per ton of train including engine	Cost of fuel per ton as put on engine including all charges for haulage	Total consumption of water	lbs of water evaporated per lb of fuel burnt	Cost of fuel per train mile	Cost of fuel per 1,000 vehicle miles	Cost of fuel per 1,000 ton miles	Kurhurbaree being assumed as unity, the results of these experiments based respectively on consumption as below show the fuel equivalent to be — Based on consumption: Per ton of train per mile	Per vehicle per mile
		1894	Miles	Hours	Miles	Miles	No	Tons	lbs	lbs	lbs	lbs	lbs	lbs	lbs	Rs A P	Gallons	lbs	Rs A P	Rs A P	Rs A P		
Kurhurbaree coal	73	May	1,208	56	151	27.45	14	151.10	33,824	1,073	2,942	4,015	28.00	2.00	15	15 10 7	26,816	7.93	0 3 2	13 15 4	1 1 6		..
	69	May	1,208	54	151	27.45	14	172.43	36,960	859	6,116	6,975	30.60	2.19	18	15 10 7	26,814	7.25	0 3 5	15 5 0	1 4 0	.	.
	57	May to June	1,208	57	151	27.45	14	175.64	39,424	1,252	6,859	8,111	32.64	2.33	19	15 10 7	27,317	6.93	0 3 8	16 4 10	1 4 10		
	60	April to May	1,208	54	151	28.76	14	185.14	33,936	881	7,256	8,137	28.09	2.01	15	15 10 7	23,088	6.80	0 3 2	14 1 0	1 1 6		..
			4,832	221	151	27.78	14	178.58	144,144	4,065	23,173	27,238	29.83	2.13	17	15 10 7	104,035	7.22	0 3 4	14 14 4	1 2 4	1.00	1.00
Singareni coal	73	May to June	1,208	56	151	28.09	14	171.48	44,576	1,120	6,324	7,445	36.90	2.64	22	13 13 4	25,567	5.73	0 3 8	16 4 10	1 5 8	..	..
	69	May	1,208	55	151	27.45	14	181.57	42,672	1,138	7,177	8,315	35.32	2.52	19	13 13 4	28,721	6.73	0 3 6	15 9 2	1 3 2		.
	57	May	1,208	56	151	27.45	14	173.18	42,784	1,649	7,308	8,957	35.42	2.53	20	13 13 4	29,018	6.78	0 3 6	15 10 0	1 4 0	..	.
	60	May to June	1,208	54	151	28.09	14	194.04	43,032	1,214	6,578	7,792	35.62	2.54	18	13 13 4	25,974½	6.04	0 3 6	15 10 10	1 2 4		.
			4,832	221	151	27.77	14	180.07	173,164	5,121	27,388	32,509	35.84	2.56	20	13 13 4	109,280½	6.31	0 3 6	15 13 4	1 3 2	1.18	1.20
Borakur coal	73	May	1,208	56	151	27.45	14	177.08	43,680	1,367	9,370	10,737	36.16	2.58	20	14 15 4	28,615	6.55	0 3 10	17 3 10	1 5 8		
	69	May to June	1,208	55	151	28.09	14	175.83	42,664	1,049	8,934	9,983	35.32	2.52	20	14 15 4	26,817	6.9	0 3 9	16 13 2	1 5 8	..	
	57	April to May	1,208	55	151	26.84	14	179.20	45,024	1,101	9,470	10,571	37.27	2.66	21	14 15 4	30,049	6.67	0 4 0	17 12 2	1 6 6	.	
	60	May	1,208	56	151	28.09	14	186.72	39,752	982	8,295	9,277	32.08	2.29	17	14 15 4	24,993	6.45	0 3 5	15 5 0	1 2 4	..	
			4,832	223	151	27.62	14	179.71	170,120	4,499	36,069	40,568	35.21	2.52	20	14 15 4	110,463	6.49	0 3 9	16 13 2	1 4 10	1.18	1.18
Patent fuel	73	April to May	1,208	56	151	27.45	14	175.16	35,352	2,464	2,788	5,252	29.26	2.09	17	23 2 11	27,991	7.92	0 4 10	21 9 10	1 11 6	..	
	69	May	1,208	56	151	27.45	14	177.67	38,080	2,494	4,577	7,071	31.52	2.25	18	23 2 11	28,544	7.30	0 5 3	23 4 6	1 13 2	.	..
	57	June	1,208	55	151	27.45	14	177.86	40,808	2,270	5,452	7,722	33.78	2.38	19	23 2 11	27,395	6.81	0 5 6	24 10 2	1 14 10	...	
	60	May	1,208	56	151	27.45	14	179.97	34,944	1,806	4,212	6,018	28.93	2.07	16	23 2 11	24,490	7.01	0 4 9	21 6 6	1 10 8	.	..
			4,832	223	151	27.45	14	177.67	148,584	9,034	17,029	26,063	30.75	2.20	17	23 2 11	108,410	7.30	0 5 1	22 12 2	1 12 4	1.00	1.03

* S C $_1$ class engines, 4 coupled, driving and trailing wheels, 5 ft 9 in. diameter—cylinders 17 × 22, boiler pressure 120 lbs

PERAMBUR WORKS;
22nd November 1894.

C. E. PHIPPS,
Locomotive Superintendent

STATEMENT B.

Statement showing Results obtained in Experiments with Kurhurbaree, Singareni, and Borakur Coals and Patent Fuel burnt in Engines working Mixed Trains between Madras-Katpadi and Madras Renigunta.

Kind of Fuel	Engine Class K B.* No	Date when the trials were made	Total miles run during the trial	Total time standing in steam during the trials	Average length of each trip	Average speed per hour	Average number of vehicles	Average weight of train including engine	Total consumption of fuel	Weight of Ashes removed: From Smoke-box	Weight of Ashes removed: From Ash pan	Weight of Ashes removed: Total	Consumption of fuel per train mile	Consumption of fuel per vehicle per mile	Consumption of fuel per mile per ton of train including engine	Cost of fuel per ton as put on engine including all charges for haulage	Total consumption of water	lbs of water evaporated per lb. of fuel burnt	Cost of fuel per train mile	Cost of fuel per 1 000 vehicle miles	Cost of fuel per 1 000 ton miles	Kurhurbaree being assumed as unity, the results of these experiments based respectively on consumption as below show the fuel equivalent to be — Based on consumption: Per ton of train per mile	Based on consumption: Per vehicle per mile
		1894	Miles	Hours	Miles	Miles	No	Tons	lbs	lbs	lbs	lbs	lbs	lbs	lbs	Rs A P	Gallons	lbs	Rs A P	Rs A P	Rs A P		
Kurhurbaree coal	137	Apl 1 to May	862	87	86	17 24	32	499 82	36 176	483	7 24	7 607	4 97	1 3	08	15 10 7	27 820	7 69	0 4 8	9 1 10	0 9 2		
	7	May	862	86	86	17 24	31	4 6 60	40 432	2 213	6 36	8 349	46 90	51	11	15 10 7	29 44	7 21	0 5 3	10 9 2	0 12 6		
	12	June	862	87	86	17 59	32	498 17	39 200	925	7 357	8 282	45 48	1 42	09	15 10 7	44 912	11 46	0 5 1	9 15 2	0 10 0		
			2 586	260	86	17 36	32	471 53	115 808	3 621	20 617	21 238	44·78	1 40	10	15 10 7	101 876	8 80	0 5 0	9 12 8	0 10 10	1 00	1 00
Singareni coal	137	May	828	84	87	16 69	35	478 66	46 480	854	7 406	8 260	53 55	1 53	11	13 13 4	28 624	6 16	0 5 3	9 6 0	0 10 10		
	12	May	862	91	86	6 90	33	474 07	5 178	1 440	10 393	1 842	55 21	1 76	12	13 13 4	45 274	9 02	0 5 9	10 14 2	0 12 6		
	7	Apl 1 to May	862	86	86	18 34	28	381 68	44 243	2 887	6 198	9 085	51 33	1 83	13	13 13 4	32 084	7 25	0 5 1	11 5 8	0 13 4		
			2 552	261	86	17 31	·2	444 80	140 901	5 190	23 997	29 187	54 36	1 70	·12	13 13 4	105 982	7 52	0 5 4	10 6 8	0 11 8	1 2	1 21
Borakur coal	137	May	868	84	87	17 01	33	487 90	42 806	727	9 547	10 274	49 42	1 50	0	14 15 4	27 470	6 40	0 5 3	9 15 2	0 10 10		
	7	May to June	828	86	87	17 71	31	492 43	45 0 8	625	7 960	8 585	51 86	1 67	11	14 15 4	32 844	7 30	0 5 6	11 1 6	0 11 8		
	12	May	862	88	86	16 58	34	501 56	44 0 6	1 019	6,169	7 188	51 06	1 50	10	14 15 4	47 499	0 79	0 5 5	9 15 2	0 10 10		
			2 558	258	87	17 10	33	490 63	131 930	2 371	23 676	26 047	50 78	1 54	10	14 15 4	107 813	8 17	0 5 5	10 4 2	0 10 10	1 00	1 10
Patent fuel	137	May to June	862	89	86	16 90	33	486 07	39 200	1 4 6	4 848	6 274	45 48	1 38	09	23 2 11	28 245	7 21	0 7 6	14 3 6	0 15 10		
	7	May	868	86	87	17 36	32	470 71	37 856	4 786	2 077	6 863	43 6	1 36	·09	23 2 11	32 308	8 53	0 7 3	14 2 8	0 15 0	"	
	12	Apl 1 to May	863	84	87	17 71	31	448 95	37 968	1 832	5 783	7 615	43 74	1 41	10	23 2 11	28 512	7 51	0 7 3	14 10 2	1 1 6		
			2 593	253	87	17·32	32	468 58	115,024	8 044	12 708	20 752	44·27	1 38	09	23 2 11	89 065	7 74	0 7 4	14 5 2	0 15 10	0 90	0 99

* K B.₁ class engines, 4 coupled, leading and driving wheels, 5 ft. 6 in diameter—cylinders 18 × 26, boiler pressure 120 lbs

C E. PHIPPS,
Locomotive Superintendent

INDIAN COAL FOR RAILWAYS

Note by Mr F E Robertson, Chief Engineer East Indian Railway, on the supply of Bengal coal to Railways

As the use of Bengal coal on the railways in this country is increasing and the freight forms the principal part of the cost it is very important to buy none but the best coal Little however, appears to be known as to the relative values of the coal and the essential difference between buying coal by name in England and in India In buying coal from mines in England the qualities of the different seams are well known and are tolerably constant, but this is not the case in India Kurhurbaree coal for instance, has and justly, the reputation of being the best steam coal yet the quality may vary from a coal containing only 7 per cent of ash to as much as 50 per cent

The notion therefore that the name of a coal in Bengal guarantees anything at all is perfectly illusory, and the only way to ensure a satisfactory result is to buy the coal on a specification of the quality to be supplied and see that the specification is adhered to There is no practical difficulty in this, as the chemical operations required for a practical analysis demand neither extensive apparatus nor any special skill

The value of coal as a locomotive fuel depends mainly upon—

(i) A minimum amount of ash

(ii) A maximum amount of fixed carbon and it is on this latter point that the average Kurhurbaree coal excels the *best* Raneegunge

The respective analyses compare as follows —

	Average Kurhurbaree	Best Raneegunge
Fixed carbon	68	54
Volatiles	23	37
Ash	9	9
	100	100

But in practice the difference is greater as but very few of the Raneegunge coals have as little as 9 per cent of ash the average is probably 15 per cent

The apparatus required to test coal consists of a covered platinum crucible, a means of heating the coal in it to combustion (a French plumber s lamp is a handy tool), and a chemical or other accurate balance The process simply consists in weighing the sample, which should be first well pounded, heating it until the escaping gas ceases to burn when the difference will give the amount of volatiles, and reheating it until the residue is converted into an impalpable ash, when the second difference gives the amount of fixed carbon The weight of a convenient sample for a chemical balance is two grammes but with inferior apparatus all that is required is to increase the weight of the sample A platinum crucible is specified because its weight does not vary and it is not liable to melt, but the tobacco pipe experiment of one s childhood shews that the resolution of the coal into its elements can be effected with quite rough apparatus

Fuel equivalents — Tests of Indian coal — Subject 3 E

It will not do to take one lump of coal and pound it up to get a fair average of a consignment Samples should be drawn from different parts, excluding any abnormal specimens such as lumps of stone, the presence of which can be detected by eye, and these should be pounded and well mixed and two or three trials made of the mixture to see that a fair average result is arrived at It may be noted that it is impossible, even with long experience, to judge a coal by eye, as a bright looking sample may turn out very heavy in ash, while a dirty waterworn specimen may give very good results

The following is the average analysis of the coals in use in addition to those already given —

	Daltongunge	Singbhoom.	Khost	Umaria.	Burma	Assam
Fixed carbon	56	56	46	45	50	53
Volatiles	32	34	50	40	37	45
Ash	12	10	4	15	13	2

It is to be noted that the volatile matter in these analyses does not always mean the same thing The volatile matter in Bengal coal is mostly heat giving, although some heat is lost by imperfect combustion in the rapid passage through the tubes In the Daltongunge and Umaria coals, on the other hand, the volatiles are principally oxygen and nitrogen, which are useless constituents for a fuel

CRACKED TUBE PLATES — SUBJECT 3 G

Note by Mr E S Luard, Assistant Locomotive Superintendent,
Bombay, Baroda and Central India Railway, dated 31st August 1894,
upon Mr C P Whitcombe s memorandum on the subject (Vol V, page 94)

In 1885 Mr W Stroudley, late Locomotive and Carriage Superintendent of the London Brighton and South Coast Railway, read a paper on the Locomotive engine before the Institution of Civil Engineers in London, and amongst other details he particularly referred to the cracking of tube plates and the quality of copper contained in them. It may, therefore, be interesting to those members of the Locomotive Superintendents' Committee who have not seen that paper, and I give the extracts referring to the question from his paper

Mr Stroudley said "the direct stay for staying the crown of the fire-box introduced by Mr Patrick Stirling A M I C E, offered so many advantages that it was adopted in the small engines class A and the result had been most satisfactory It was then applied to the D and E classes, where it answered fairly well but had not given such good results These stays are not used now for the large classes of engines, as they were found unsuitable for a deep fire box, causing the tube plate to break down at the upper flange and producing cracks between tube holes The author therefore returned to the girder roof bar, and he believed a direct stay would not be found to answer in any but small fire-boxes He gave the corners of his fire-boxes large curves, and the stays to the outer shell were kept as far from the corners as possible By placing the first vertical row of stays 2 inches from the end of the tangent, the plates both copper and iron have room to yield to the expansion of the straight sides, this prevents a vertical groove forming in the inside of the iron plate and also prevents cracking in the corner of the copper fire box Not one of these fire boxes had cracked in the corner up to that time.

"The author had noticed that *pure copper was not so good* for a fire box as copper containing some remains of tin and other impurities which gave the copper hardness, copper which is so hard that it will break easily, yields the best results

"The copper tube plate is countersunk in tube holes with a bell mouthed tool on the side next the water, and also on the side next the fire, leaving a parallel portion ⅜th of an inch only for the seating under the tube This permits the water to keep the plate cool and also obviates the nipping action which has been found to break the tubes close to the plate when the edges of the holes are left sharp They are rolled out with a Dudgeon expander and then set out and flanged over without risk of fracture with tools specially designed for the purpose When brass tubes are used, they are *bent upwards in the centre* to about their own diameter, so that the expansion may not force the tubes through the stay and cause leakage This has been found a very efficient remedy for leakage of tubes, but when iron or steel tubes are used, the differential expansion is so small that this bending is not necessary"

Locomotives — Cracked tube plates — Subject 3 G

In the course of the discussion on this paper Mr Deane, Locomotive Superintendent of the Great Western Railway remarked that "these conclusions with reference to direct stays had been pretty generally correct with large boilers it has been found undesirable to continue that method of staying

Mr Aspinall, Locomotive Superintendent, Lancashire and Yorkshire Railway, remarked that 'with regard to the amount of expansion of brass tubes when under steam pressure in trying a boiler over a len th of 9 3 that it expanded $\frac{1}{16}$th of an inch, and that the tube in a length of 10 4" expanded about $\frac{7}{16}$th, and one tube placed in a stuffing box at the smoke box end expanded a $\frac{1}{16}$th in addition, thus showing that the tubes would, if they were allowed, expand something like $\frac{1}{2}$" '

WEHRENFENNIGS FLEXIBLE STAYS — SUBJECT 3 H

(See also Vol II, pages 63 and 65)

Abstract of correspondence between the Locomotive Superintendent, Burma State Railway, the Manager Warora Colliery, and the Locomotive Superintendent Great Indian Peninsula Railway

No 1

Letter dated 5th October 1891 from Locomotive Superintendent, Burma Railway to the Manager Warora Colliery enquiring if he can give any information regarding an engine on the Wardha Railway which he fitted with those stays (about 1882 or 1883) The tube plate was then badly distorted, but no bridges broken

No 2

Letter dated 7th October 1891 from Locomotive Superintendent, Burma Railway, to Locomotive Superintendent, Bengal Nagpur Railway asking for a copy of the drawing of the stays put in

No 3

Letter dated 22nd October 1891, from Locomotive Superintendent Bengal Nagpur Railway, forwarding the drawing

No 4

Letter dated 5th November 1891, from Manager, Warora Colliery, stating that he is unable to give the information asked for as the Wardha State Railway had been transferred to the Great Indian Peninsula Railway

No 5

Letter dated 24th May 1892 from Locomotive Superintendent, Burma Railway, to the Manager, Warora Colliery, enquiring whether he can inform him what has become of the engine in question

No 5 A

Letter dated 7th April 1894 drawing attention to No 5 and requesting the favour of a reply

No 6.

Letter dated 18th April 1894, from the Manager, Warora Colliery, to Locomotive Superintendent, Burma Railway, stating that the engine to which these stays were fitted was examined, and the stays found useless, as the expansion space inside the cap nuts was filled solid with sulphate of lime deposit The engine had been purchased by the Great Indian Peninsula Railway when the line was made over to them

Locomotives — Wehrenfennig's flexible stays — Subject 3 H

No 7

Letter dated 9th May 1894 from Locomotive Superintendent, Burma Railway, to the Manager, Warora Colliery, pointing out that though this space had been filled up solid, a good deal of transverse flexibility would still remain and enquiring whether the stays were still in when the engine was made over to the Great Indian Peninsula Railway, to which the Manager, Warora Colliery replied that they were

No 8

Letter from the Locomotive Superintendent, Burma Railway dated 15th June 1894, to the Locomotive Superintendent, Great Indian Peninsula Railway, forwarding copies of above correspondence and enquiring whether he can add any further information on the subject

No 9

Letter dated 12th September 1894 from the Locomotive Superintendent, Great Indian Peninsula Railway to the Locomotive Superintendent, Burma Railway

I beg to state that the engine fitted with the Wehrenfennig's stays referred to bears at present Great Indian Peninsula Railway No 49 When this engine was handed over to us from the Wardha line the boiler barrel, top of copper fire box and sides of fire box were found considerably choked with deposit, and the sides of the fire box were bulged between the stays owing to the same A new copper tube plate was fitted and the whole of the roof bars were taken off and refitted The Wehrenfennig's flexible stays were left in their places and are still running with the engine

2 I have recently had three of the cap nuts removed in order to ascertain the condition of the expansion space The foreman, who made the examination, reports that the expansion space was found clean and free from deposit He also remarks that he found it a most difficult matter to remove the cap nuts without injuring the stay and its seating, as the screw of the cap is so much larger in diameter than the screw portion of the seating which fits into the casing plate, that any attempt to unscrew the cap causes the screwed portion of the seating to turn also The stay head prevents the seating from being removed and this is apt to result in the thread of the seating portion eventually stripping None of these stays have broken or given trouble since we have had the engine which, however, has not run a very extended mileage

No 10

Letter dated 25th September 1894, from the Locomotive and Carriage Superintendent Burma State Railway, to the Locomotive and Carriage Superintendent, Great Indian Peninsula Railway

I am much obliged for your interesting report which I think shows that flexible stays stand well

The difficulty you refer to about the seating slacking back when the cap is unscrewed was I well recollect discovered very soon after the engine was fitted It was an error in design that the seatings were not provided with hexagon sides for a spanner to be used for holding on when unscrewing the caps

Leach's system largely used on the Rajputana Malwa Railway,* gets over this difficulty in a very much neater way but the general principle of his stays is taken from Wehrenfennig's I have it in successful use here on two engines

* See Vol. II pages 63 and 65

WEHRENFENNIGS FLEXIBLE STAYS—SUBJECT 3 H

(See also Vol II, pages 63 and 65)

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* See Vol. II pages 63 and 65

MINIMUM DIMENSIONS AND FASTENINGS FOR LOCOMOTIVE TYRES — SUBJECT 3 N

Copy of a letter from C E Phipps, Esq, Locomotive Superintendent Madras Railway, dated Perambur 5th October 1894, to A W Rendell, Esq, representative of Sub Committee for Locomotives

I would beg to suggest that the question as to the minimum thickness at which locomotive and tender tyres shall be allowed to work and also the method by which they shall be fastened to the wheel skeletons should be taken up by your committee and brought forward for discussion and if possible, for settlement at the Calcutta meeting

2 The minimum thickness for carriage and wagon tyres and also the system by which they are to be fastened have been very fully considered and standards for each condition have been more or less practically decided upon but in the case of locomotive engines and tenders where really it is equally, if not more important that an ample margin of safety should be secured, the question has not been, so far as I am aware, even touched

3 The minimum thickness for locomotive tyres allowed on the several lines seems, from information I have recently obtained to vary from a maximum of 1⅜" to 1¼", tender tyres being allowed to run down in some cases to 1¼" so far as I know, all tyres, both engine and tender, are fixed by bolts or rivets or by some combination of bolts and a single continuous lip

4 I am sending you a tracing showing the system of fastening in force on this line, and I also send you a full size model of the same thing It will be noticed that in this arrangement the threads on the point of the set screws or bolts have been cut away, leaving a circular pin alone as it were to project into and keep the tyre in its place This modification was adopted as it was found impossible to keep the bolts from failing if they were screwed into both the skeleton and tyre since, as the tyre expanded under the action of the brake it worked so to speak on the skeleton, or rather the slack place ran round the outside of it as the wheel turned round and either so damaged the threads of the bolts that they could not be kept in their place or broke them off altogether Under the present system this is avoided, as the tyre, though prevented from moving sideways by the plain part of the bolts fitting into the holes in it is free to move circumferentially as it expands. It was hoped that this had got over the difficulty, but I am sorry to say this is not so, and I find that the continual expansion and contraction still damage the bolt ends and they either wear away until they are too thin to do their work or else shear off flush with the skeleton I am now putting in extra bolts wherever necessary but I fear this is but a temporary remedy, and it seems to me that some system of ring fastening is as necessary for engine and tender tyres as it is for tyres of coaching vehicles, and I should be very glad if some standard fastening could be agreed upon

5 I forward you a drawing showing a system that I have recommended for adoption on certain new engines now under order for this company, but, though it is perhaps the simplest and most effective that has come under my notice, I am not satisfied with it as it does not prevent the skeleton from turning round inside the tyre Of course this might

be got over by inserting bolts in the same manner as is now being done and as is described above, but I fear that they would share the same fate in the ring fastened tyre as they do now in tyres with a lip on one side only

6 The subject is one generally of considerable interest and I should be very glad if it could be brought up for discussion

(Reports on the fastenings of engine tyres will be found in Vol IV, page 60, and III, page 91)

WEIGHT OF LOCOMOTIVES AND ROLLING STOCK — SUBJECT 3 O

Copy of a note from Mr J R Bell, Consulting Engineer to the Government of India for State Railways, dated November 1894
to the Chairman of the Committee of Locomotive and Carriage Superintendents.

Before I can attempt to open the subject with the Government of India of your Committee's enquiry how far special live loads will be sanctioned in extreme cases it is necessary for me to be perfectly assured on two points, *viz*, (1) that expert opinion is itself of accord as to practical finality, and (2) that managers are prepared, after counting the cost, to work up to such enhancements on an extended scale. In order to focus, in the first instance your opinions, in the second those of engineers, and, in the third, of those with whom financial responsibilities rest, I think, it on the whole best to expound the considerations on which my personal views now rest,—by way of a tentative basis for academic discussion

2 It is, and has long been, fairly obvious, as a general proposition, *that under similar conditions of climate cost and class of traffic, definite proportions ought to subsist as to maxima between axle loads wheel and journal diameters, axle spacings, the road, and bridges, etc* In fact however until very recently wide divergence of practice has obtained on even the uniform normal 4 ft. 8½ in gauge of the world at large, and it is only after costly if not hazardous experiment that normal gauge practice has lately settled down to such practical accord as may justify the Government of India in fixing absolute standards

Another reason for a tentative policy lies in the fact that in India we have two special gauges —one larger and the other smaller than the normal gauge which serves practically the rest of the civilised world It is settled elsewhere *that the least objectionable mode of differentiating feeders from main lines is to maintain unity of gauge and run the same vehicles at lower speeds with lighter engines over weaker roads on substructures capable of being raised to mainline standards without serious interruption* This Government with two established gauges has found it alike impossible either to compass this policy or to ignore it and, with varying purpose under changing administrations, has at times agreed to measures which made for ultimate unification and at other times to demands which tend to widen the gap Latterly however the foundations of a settled purpose, which only requires time and opportunity to work its end have been laid metre gauge feeders are being linked into great main arteries their future substructures are to be so spacious that either the gauge can be widened or the narrow gauge loads can be materially enhanced without a too serious dislocation and there is every prospect that the metre gauge will in a very few years work out its destiny to an irrefutable conclusion in one sense or the other

For ultimate unification on the standard (5 ft 6 in) gauge of this country one rock ahead consists in the extravagant ambitions which seek to expand standard gauge loads *pari passu*, with metre gauge demands For my part I am of those who hold the main if not sole advantage of the 5 ft 6 in gauge over 4 ft 8½ in to consist in its allowing us to carry the same loads which satisfy the whole civilised world beside *with greater economy in the life of our material* Having adopted the same standard size of vehicle wheel as England I hold that we stand absolutely committed t[illegible] above view, and to go beyond the English high watermark of economical live [illegible] to me, apart from our gauge difficulties, unnecessary and [illegible]

Weight of Locomotives and Rolling stock — Subject 3 O.

3 Taking the various factors named in paragraph 2 consecutively, I come to the admissible relation between *axle loads and wheel diameters* which depend on the abrading and crushing action of tires on rails For estimating the girder strength of a pair of rails we assume the axle load to lie as it were on knife edges at the centre of the span between two sleepers but in fact the incidence of the rolling wheel falls out of centre on the side towards which it travels and is *distributed* in a degree which corresponds to the wheel s diameter while its intensity varies with the load the speed, the '*period*' of the springs the length of the rails and the liability to lurching and 'galloping' *As far as I see, the goods vehicle wheels now being put into broad gauge service with 12 ton axle-loads and 3 6 feet diameters mark the high tide of extreme practice* and calling L the axle load in tons and D the wheel diameter in feet I think an equation

$$L \leqq \frac{10 D}{3} \quad \ldots \quad (1)$$

gives a workable absolute limit, albeit empirical

D is for broad gauge fixed at a practical maximum of 3 6 feet, while on metre gauge $D_1 = 2$ feet admitting 6 6 tons is going out of vogue, $D_2 = 2\ 3$ feet, which is now in general use, would carry 7 7 tons and if required I think $D_3 = 2\ 5$ feet might be admitted on metre gauge as comparable to 3 6 feet on 4 ft 8½ in gauge which would on this rule carry 8 3 tons

Equation (1) should I think apply exclusively to goods vehicles and goods engines (The journal diameters are matters with which your committee is already dealing It is to my mind a comfort to reflect that owing to continuous wear of tires and journals the number of vehicles that can carry the maximum loads this rule would sanction will be but a fraction of the whole stock of any line)

For coaching vehicles—which should I consider, include all braked stock, all engine-tenders and all mixed engines—the above equation should stand

$$L_m = \frac{10 D}{3 5} \quad \ldots \quad (1a)$$

admitting 10 tons on 3 5 feet wheels—down to 5 7 tons on 2 feet wheels.

For express engines English practice appears to barely sanction

$$L_e = \frac{10 D}{4} \quad \ldots \quad (1b),$$

or 15 tons on 6 feet wheels

If there is any difficulty in defining goods mixed and express engines, may I suggest that as I understand it a goods engine has at least three driving axles and wheels not exceeding 2½ strokes in diameter a mixed engine has at least two coupled driving axles and wheels not less than 2½ nor more than 2¾ strokes in diameter, and an express engine has larger wheels than 2¾ strokes in diameter whether coupled or single d[illegible]en

Calling G the gauge in feet $\qquad L = \frac{10 G}{3}$

might I think be an absolute maximum for any gauge whatever, giving 11 tons on metre, 16 tons on English and 18 tons on Indian gauge

4 *Axle spacings* apart from the adequacy of the road, etc., depend on traction resistances and on avoiding 'g[illegible]ping' Very recent scientific experiment has determined that the least tractive resistance on curves in common use, is experienced where the rigid wheel base is equal to one and a half gauges say 5 feet for metre, and 8 ft. 3 in. for broad gauge Roughly [illegible] foot *of less wheel base* is as bad as three feet extra, and it is fairly plain that wh[illegible] bo[illegible] tr[illegible]ks a[illegible] very appropriate on metre, they are somewhat out of place on broad gauge l[illegible] [illegible] actice has determined and agrees closely with the above, that the wheel base of any ve[illegible] should be at least half its gross length over buffers—on broad gauge two gauges o[illegible] [illegible] wagons, and three gauges or 16 ft. 6 in. for coaches—on metre, three ga[illegible] wa[illegible] a[illegible]d three and a half gauges or 12 feet nearly for coaches For broad gau[illegible] it is fairly clear that the total wheel base must be-

at least three gauges for goods three and a half gauges for mixed and four gauges for mail engines, and it is better if the total wheel base be more extended, although five gauges including flexible base appears to be outside practice on the normal gauge In terms of the gauge there is no doubt that metre gauge requires greater length—a point on which I particularly request your committee's views

Apart from the above considerations on total wheel base any two consecutive axles must be wide enough apart to leave room for flanges, brake gear, etc, in addition to the diameters provided under equation (1) Here if L be the maximum axle load in tons and S the axle spacing the proper equations seem to be

in coupled goods engines $S \geqq \frac{2L}{5}$ ... .. (2)

in mixed engines $S \geqq \frac{2L_m}{4}$ . .. (2a)

and in mail-engines $S \geqq \frac{2L_r}{3 5}$ ... (2b).

Here I may suggest that in coupled engines L in terms of equation (1) should be an absolute maximum, and that where there are no pilot wheels to take off the shock of galloping as in *e g*, a six coupled engine without free leading wheels, the leading axle should not carry more than 90 per cent of the maximum axle load

5 The *road* is a subject on which recent French experiment and German analysis have thrown considerable light Its conditions very singularly resemble those of a floating raft, where the combined elastic resistances of rails, chairs, sleepers, ballast and subsoil *combine to support loads which would inevitably destroy rails set on rigid supports* The early destruction of sleepers and rails in rock cuttings and the demand for a 'cushion' over arches sufficiently attest the importance of the elastic factors of subsoil and ballast, although for our present purpose this paper must content itself with assuming them adequate, merely mentioning that on double lines the inner rails stand so much better than the outer as to prove that a wide embanked formation is a most important factor in the durability and good order of a single line

As to *sleepers* it is well known that 21 inches on either side of either rail is all that can be advantageously *packed* with stout and new cross sleepers, a figure which rarely exceeds 18 inches in practice and comes down as the sleepers become more tender with age to 15 and even 12 inches It would thus appear that 3 ft 6 in in excess of the gauge is about all the length of sleeper that can be advantageously used on any gauge whatever, or twice the distance between rail centres whichever is least This would admit 5 feet sleepers for 2 ft 6 in gauge say 7 feet for metre, and 9 feet for the 5 ft 6 in gauge On the smaller gauges while the axle loads are less and also the speeds the want of lateral stability and tendency to lurch is greater, and I incline to think that on both metre and broad gauge (with maximum loads) the same scantling of sleeper, which I would prefer to see 9 in × 6 in in place of 10 in × 5 in, is necessary to economy and even to safe running Such cross sleepers cannot well be spaced closer than 27 inches between centres on any gauge even at the joints

Taking *chairs and rails* together the effect of chairs in absorbing and distributing shock over sleepers is so material that an English 84 lb chair road is even more durable and efficient than a Belgian road on the same gauge with 100 lb goliath rails On Indian broad gauge, which happens to be wider than the normal in about the above ratio of 100 to 84, rolling shocks are proportionately less and we are able to either eliminate the chair, where we use Vignolles rails on wood, or the wood when we expand the metal chair into a pot, plate, or peascod sleeper, and yet get about the same advantage from our rails, pound for pound, as in an English road Calling the maximum goods axle

Weight of Locomotives and Rolling-Stock. — Subject 3 O.

load in tons, L, as before and the weight per yard of rail in pounds W, practice appears to sanction for the normal gauge of the world an equation of

$$W \quad = \quad \frac{20}{3} L \quad .. \quad (3)$$

which demands rails of 80 lb for 12 ton vehicle axles, 70 lb for $10\frac{1}{2}$ *tons, 60 lb for 9 tons, 50 lb for* $7\frac{1}{2}$ *tons, and 40 lb for 6 tons, for wheel diameters according to equation* (1)

Here between 60 lb rails carrying 9 ton axle loads and 50 lb rails carrying $7\frac{1}{2}$ tons, the two gauges may be said to meet It is certain that inferior 60 lb iron rails on the 5 ft 6 in gauge have carried 9 ton goods axles well for years but on wheels not smaller than 3 5 feet diameter It is I think possible that a 56 lb rail of steel in 30 feet lengths,—for increased length of individual rail is known to materially strengthen the whole road [illegible] rail joints by dint of *encastrément* which, when complete, shortens the effective span of rail from sleeper to sleeper to three fourths of the actual distance—may, with greater wear and tear, carry 8 3 tons on 2 5 feet wheels in spite of the lurching forces due to [illegible]

As you will doubtless observe Rule (3) is correlated to Rule (1) and

where $L = \dfrac{10\ D}{3}$, I propose $W = \dfrac{20\ l}{3}$

for mixed engines where $L = \dfrac{10\ D}{3\ 5}$, I would allow $W_m = \dfrac{20\ l}{3\ 5}$ (3 a)

and for mail engines where $L = \dfrac{10\ D}{4}$, would make $W_s = \dfrac{20\ l}{4}$ (3 b)

The last factor would allow axle loads of 16 tons on 80 lb rails and [illegible] rails with large wheels, and I am very confident that in the few cases when [illegible] are exceeded the roads will be found to suffer out of all proportion to the [illegible]

6 I do not claim that the above suggestions are based on absolute scientific [illegible], and am well aware that others may be found which more accurately represent the [illegible] conditions in possibly a simpler form but they illustrate my general views [illegible] portant questions and I should be glad if your committee would after accepting [illegible] ing them, bring out diagrams of the heaviest engines tenders goods stock [illegible] stock proposed for each class of road The question of whether or not [illegible] in your view for a metre gauge road heavier than 56 lbs except on ghâts [illegible] ventilation For managers it will be fraught with this consideration that [illegible] tion will certainly involve complete reconstruction of bridges up to the new [illegible] standard, for the proposed live loads on shorter wheel bases come very close to [illegible] weights and their destructive action by dint of lurching will be appreciably greater

Another point on which I desire to have an opinion is the maximum length of engine weights for which bridges should be designed It appears possible owing to greater facility for strengthening couplings to attach a greater proportion of engine power to a metre gauge train than to a broad gauge where direct [illegible] in question On ghâts the case is different but there it seems quite possible that trains which ascend with one hauling engine and two pushers may descend with three engines coupled in front—probably tank engines—on either gauge

As I have said above I think tenders should follow coaching stock in the matter of wheel diameters Perhaps you can tell me what advantage if any other than [illegible] short turn tables, results from keeping tenders short and heavy. It is out of the question that doing so can appreciably affect the curve resistance of a train though it may very intimately affect the loads of bridges I incline to believe that whatever types of [illegible] engines may be evolved, their excess loads might be restricted to 100 feet run on either gauge—a point that would [illegible] bridge design

Weight of Locomotives and Rolling-Stock — Subject 3-O.

Copy of a letter, dated Lahore, 9th April 1895, from Mr C T. Sandiford, Chairman of the Committee, to the Secretary, forwarding his reply to Mr J R Bell's note.

I beg to enclose a note on Mr. J. R Bell's proposals on subject 3 O *(pages 34 36 of the preliminary issue of the Calcutta meeting)*. The more I looked at it the more difficult the paper appeared to answer, for based as the formulæ are on examples actually found in good practice, they are capable of refutation on precisely the same grounds. That the rules as they stand would have been most valuable had they been in force during the last 20 years is pretty evident, but finding no such restrictions, men went off the track, which makes it difficult now to embrace them in so small a compass It is easier to captiously pull the paper to pieces than to substantiate it, for as I have said, it is mainly founded on practice, which varies enormously. Notwithstanding this I believe it is quite possible to frame rules such as Mr Bell proposes Perhaps the greatest difficulty in the paper is the acceptance of the proposition in second paragraph, I greatly doubt that there is any such agreement, but I am in favour of some understanding being come to, and hope the replies will not be so divergent as to prevent a consistent answer being compiled I certainly think it is due to Mr Bell and to the Committee that it should receive the fullest consideration in Sub-Committee

Note by Mr C. T Sandiford on Mr J R Bell's proposals for weight of Locomotives and Rolling stock.

(1) It appears to me that at the very outset one of the greatest difficulties which faces an investigator, dealing with the very able exposition which Mr J R Bell has put before the Locomotive and Carriage and Wagon Committee, lies in its intensity He has practically reduced to very simple formulæ much that has hitherto been scattered over an immense field, and condensed to an expression details which have been the subject of widely divergent opinions The terseness with which he puts the matter before the Committee must force individuals into feeling how small an influence they can really have in fixing designs that may survive, but it must also make men hesitate to accept and be bound by rules acknowledgedly empiric His formula certainly agrees with good existing practice, but there would be no difficulty in fitting in different equations supported by excellent examples

2 The questions put in the opening paragraph of his note,—did they not carry so much behind them —would be comparatively easy to answer To the third or financial one, I offer no opinion, beyond the remark that I believe the Managers are very largely in the hands of their professional advisers, who are mainly *responsible* To the question "Is expert opinion itself of accord?" I certainly do not think we can say it is prepared to recommend a very great deal that is tentatively accepted as common practice, and submit that it is only quite recently that any serious attempt has been made at unification, broadly speaking each man, although instructed by those who have gone before, follows his own bent This process of evolution is always going on and on the principle of the survival of the fittest, the best practice should by degrees become general

3 Considering the equation $L = \frac{10\,D}{3}$ it naturally occurs might a goods wagon with 12 tons axle load and 3 6 feet wheels be allowed (if the expression is accepted) to carry a greater load on a larger wheel? I certainly do not think it should, and hold that 12 tons should be the absolute limit for the axle-loads for goods stock, and I doubt if increasing the size of the wheel (carrying as it would a corresponding increase in load)

would improve matters, and opine that the range which it admits in consignment between the 3-ton *minimum* and the *16 tons maximum the wagon will carry, is too great to attain* economy in working. The very wide range of load and high maximum necessitates a strong and consequently heavy wagon; it also prevents, if indeed it does not absolutely bar, the use of lighter vehicles, for they cannot live among the heavier and stronger sort.

I concur in considering that equation (1) should apply exclusively to goods stock, and think that the limitation in equation (1 *a*) is sound and desirable, also the restriction imposed by gauge in formula-$L \leqq \frac{10\,G}{3}$.

The proposed definitions for mixed and passenger engines should, I think, meet the case; personally I approve of it also for goods engines, but I know that 2¼ times the stroke would exclude a large group of goods engines, 5 feet being fairly common (*with 26 inch stroke this gives a ratio of about 2⅓, and with 24 inch stroke of 2½*).

In giving my general adherence (with the exception just noted) to the rules in paragraph 3, empirical though they be, I am bound to say that they exclude some excellent designs; they are at the same time based on good modern practice, and if followed would allow a good deal of freedom in design, and guarantee thoroughly useful engines.

Axle spacing.—I concur with the whole of paragraph (4) up to the opinion that broad gauge engines should have a wheel-base of at least 3 times the gauge for goods and 3½ times for mixed. I do not follow the reasons which lead to this conclusion. Indeed the statement in the first part of the paragraph is directly in opposition to it, and provided the per foot-run and axle-load limits are not exceeded, I do not see why 3 times the gauge should be imposed, indeed, except in bogie engines, so long a base is rather unusual. I either have missed the point or fear it is a detail that requires a little more light, nor is it clear that the equations (2), (2*a*) and (2*b*) are in accord.

The recommendation to keep down the weight on the leading pairs of wheels in 6-wheel goods engine can be followed with advantage to the road for the reason advanced, but I do not find that in English practice it has been admitted either in goods or mixed engines, probably because the light of research referred to had not shown up the objections, and there is no disputing that engines heavy by the head are good pullers.

The whole of the valuable detailed information on the *Road, Sleepers, Chairs,* and the relation they bear to the engines and stock is most instructive and interesting and although more immediately the business of the Civil Engineer is of that practical sort the promulgation of which cannot but be useful to the locomotive and carriage officers, for there is not the slightest doubt that designing engines and stock without keeping the character of the road in view, leads to radical mistakes. The enquiry on the maximum engine weight that bridges should be designed for? So far as I can see there is no occasion to ever have more than three engines coupled on to one train, and it is only on bridges of over 100 feet span that it really becomes important. On slow trains I advocate permission to use three engines coupled; it is often convenient to do so, but see no reason to exceed that number. On ghât lines, where special engines are used, such engines do not usually measure much more than 32 feet over buffers and run just on 2 tons per foot.

I see no object in making very short heavy tenders. I believe with engines like the L class, it was done to admit of old turntables being used. Experience on the North-Western Railway shows that tenders with 12 feet wheel-base run much better than those with only 10-feet base.

Weight of Locomotives and Rolling-Stock — Subject 3-O.

Although in writing this note, I have been obliged to scrutinise locomotive and carriage practice, I have purposely refrained from introducing figures and quoting examples for or against the conclusions drawn. I have taken the question up with a desire to come to some definite understanding, and if possible accept some general rules to guide designers and so save confusion, and I hope the collation of opinions by the Sub-Committee who will deal with the replies received from the different members may result in useful work.

WEIGHTS OF LOCOMOTIVES AND ROLLING STOCK — SUBJECT 3 O.

Report of the Railway Commissioners for New South Wales for the year ending 30th June 1894

The following information regarding the locomotives and rolling stock in use on the railways in New South Wales has been extracted from the above report. The lines in this Colony are 4 feet 8½ inch gauge, and where the line is double and at stations, the tracks are laid 11 feet 1½ inch centres Out of a total of about 2 500 miles 631 miles are on grades of from 1 in 30 to 1 in 75, with curves of 8 chains (528 feet) and 10 chains (660 feet) radius, the heaviest grades and sharpest curves being on the trunk lines over the Blue Mountains

The old permanent way, with iron rails of 75 lbs laid in 25 lb chairs on sleepers of small scantling, is being replaced by 80 lb. bull headed steel rails in 45 lb chairs on iron bark sleepers 9 feet long by 10 inches by 5 inches, with ballast of hard and heavy blue stone laid over the old inferior sandstone ballast

The passenger vehicles are of the bogie pattern some being of the Pullman type with end platforms, and others with side doors the former vary from 8 feet 11 inches to 9 feet 4 inches wide, the latter are 8 feet 6 inches wide The covered goods vehicles are 9 feet wide, and both bogies and four wheelers are used Examples are given of some of the open goods vehicles a bogie vehicle is 32 feet by 8 feet 8½ inches over body, weighs 11 tons 7 cwt, and carries 23 tons a four wheeler is 16 feet by 8 feet 8½ inches over body weighs 5 tons 16 cwt and carries only 10 tons There is no apparent reason why the latter should not carry half as much as the bogie as it is half the length and only slightly over half the tare, though it is fitted with the Westinghouse brake and the bogie apparently is not

The Westinghouse quick action brake is fitted to all vehicles for carrying live-stock, and the goods vehicles are being fitted

Weight of Locomotives and Rolling-Stock. — Subject 3-O

The "B" class American Consolidation Engine, 1890 pattern, has outside cylinders 21 inches by 26 inches 8 coupled wheels 4 feet 3 inches diameter, and 2 wheeled bogie leading with wheels 2 feet 6 inches diameter The weight in working order is 62 tons 12½ cwt, of which 56 tons 15¾ cwt are on the coupled wheels, the greatest load on a pair being 15 tons 9 cwt on the drivers The rigid wheel base of the 8 coupled wheels is about 13 feet 6 inches

The tender is on two bogies and weighs 34 tons 10½ cwt., carrying 3 650 gallons of water and 6 tons of coal

The boiler pressure is 160 lbs per square inch, and the grate area 32 square feet The engine will take 350 tons exclusive of engine and tender, up 1 in 40 at 10 miles an hour, as against 230 tons hauled by the older type of engine with cylinders 18 by 26 and 6 coupled wheels 4 feet diameter, with two wheeled bogie leading, the weight of which is 46 tons 10 cwt, and a 30 ton tender

An improved engine of the English pattern has been designed for this work, combining the good qualities of the American "B" and English locomotives This has practically the same weight and dimensions as the American engine except that the grate area is reduced from 32 to 29¾ square feet, the heating surface of fire box being increased, and the bogie wheels are increased from 2 feet 6 inches to 2 feet 9½ inches This engine is expected to be able to haul a slightly heavier load on grades of 1 in 75 or flatter than the "B" class

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Extract from a letter dated London 28th September 1894 from Sir A. M Rendel to the Director General of Railways

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The Mex can line where it is not 1 in 25 or 1 in 33 is for the most part 1 in 66, up and down, except for a few miles near Vera Cruz* It is laid with 62 lb steel rails now getting on in life But *on the Ghauts* we are *now* relaying the line with 82 lb rails

The engines used for some years past on the Ghauts are over 92 tons weight (Fairlies) with 46 tons on each bogie wheel base 8 feet 3 inch We are now sending out 93½ ton Fairlies On the flatter parts of the line we use as heavy ordinary engines as we can build The curves on the Ghauts are, some of them 330 feet *combined* with 1 in 25 and 1 in 33 gradients The length of these gradients is about 33 miles (all together in one length)

The line is altogether one calculated to try any permanent way especially seeing that the rails are so light The gauge is 4 feet 8½ inch for which reason the steel sleepers weigh only 1 cwt In other respects they are like yours with plain clips and no distance pieces

* See Vol V page 173 On page 174 it is stated that the diameter of the wheels of the old 85 ton engines is 42 inches and that they have been running for years on 62 lb steel rails laid on wooden sleepers about 2 000 to the mile.

WAGON LABEL HOLDERS — SUBJECT 5 C

Copy of a letter dated 5th June 1894 from C. E Phipps Esq Locomotive and Carriage Superintenden, Madras Railway, to R Pearce, Esq, Representative of Carriage and Wagon Sub-Committee

As you may probably be aware, a question was brought up at the Madras Meeting, at the request of our Traffic Manager, that steps should be taken to, if possible, introduce a standard holder for wagon labels or direction cards It was agreed that until the various Traffic Managers had settled between themselves the size of the label that should be adopted universally there was not much use in the Carriage and Wagon detail Committee designing a socket to hold it and I was requested to write to our Traffic Manager to this effect This was done, and after considerable correspondence I am now informed that the following railways agree to adopt a label 5 in × 3½ in —

Madras Railway
Indian Midland Railway
Bengal and North Western Railway
East Indian Railway
Eastern Bengal State Railway
East Coast Railway
Oudh and Rohilcund Railway

The following railways use a label 5 in × 4 in, so that their sockets would take standard labels of 5 in × 3½ in —

Great Indian Peninsula Railway
South Indian Railway
Southern Mahratta Railway
Bengal Nagpur Railway
Nizam's Guaranteed Railway

The North Western Railway has not replied, and the Bombay, Baroda and Central India Railway prefer 4½ in × 3½ in Practically, therefore, all the large lines in India, excepting the Bombay, Baroda and Central India Railway, would agree to a label socket to hold a label 5 in × 3½ in

There is no doubt it would save a good deal of trouble to the Traffic Department if some standard could be agreed upon and I would suggest that your Committee prepare a design of one standard label socket of the size mentioned for general adoption I forward for your information half a dozen ferrotypes of a label holder that seems to meet the requirement mentioned

Copy of a letter dated [illegible]th March 1894 from the Traffic Manager, Madras Railway, to C. E Phipps Esq Locomotive and Carriage Superintendent.

You will see from the attached list* (see page 151) that the majority of the railways are in favor of, or prepared to adopt, wagon labels 5 in. × 3½ in

* The Great Indian Peninsula Railway have one in use 4½ in × 3½ in., but do not say whether they will adopt the card agreed to by the majority, nor do they make any suggestion The result of the canvass has been notified to the General Traffic Manager, and he has been asked to adopt cards 5 in. × 3½ in.

Wagon label holders — Subject 5-C

The North Western Railway have a label $4\frac{1}{2}$ in $\times$ $3\frac{1}{2}$ in and do not wish to make any alteration I have asked them to reconsider the matter and advise their Locomotive Superintendent and myself The Bombay, Baroda and Central India Railway also are in favor of $4\frac{1}{2}$ in $\times$ $3\frac{1}{2}$ in and are prepared to alter their size, which now appears to vary from $3\frac{1}{2}$ in $\times$ 3 to 4 in $\times$ 3 in Accordingly they have been asked to adopt the 5 in $\times$ $3\frac{1}{2}$ in and advise their Locomotive Superintendent

The cards 5 in $\times$ $3\frac{1}{2}$ in are a very useful size and much preferable to our present labels I hope therefore you will have no difficulty in getting the Locomotive Superintendents of other companies to adopt suitable holders at an early date.

If the opening in the holders enables the staff to read all the information shown on the card, it will be a great convenience

Perhaps you will not object to let me see a sample before casting

If you can also arrange to allow the old holders to remain on the wagons until the old labels are exhausted, it will enable the station masters to use those on hand, whether of the new or old kind

The General Storekeeper has not been asked to alter our style, but this will be done directly I hear when the holders are likely to be fixed.

Copy of a letter No L 88331 dated 12th June 1894 from the Traffic Manager Madras Railway to the Locomotive Superintendent

Your No B $\frac{195}{3351}$ dated 11th June 1894

Referring to your letter quoted above I regret to state that the Bombay Baroda and Central India Railway still adhere to the opinion that a wagon label holder $4\frac{1}{2}$ in $\times$ $3\frac{1}{2}$ in or $3\frac{1}{2}$ in is preferable to the size proposed The North Western Railway I have been able to get no reply from The Great Indian Peninsula Railway wish to retain 5 in $\times$ 4 in, and as this will take our proposed 5 in $\times$ $3\frac{1}{2}$ in card, we need not object to it The Indian Midland Railway already have 5 in $\times$ $3\frac{1}{2}$ in holders and, as explained to you in this office letter of 17th March last all the other broad gauge railways have either definitely agreed to adopt this size or have stated their willingness to adopt it if the majority do so

I do not think I can now carry the matter any further and must ask you to take it up with the Locomotive Superintendent's Committee So far as this railway is concerned, it will not affect us very seriously if the Bombay, Baroda and Central India and North Western Railways decline to go with the other lines, as we do not receive many of their wagons I should like to hear early if the size is definitely accepted, as our stock of wagon labels is running out and will shortly require to be renewed

Wagon label holders — Subject 5-C

RAILWAYS	Present size	Proposed size	REMARKS
1 Bengal-Nagpur	5 in × 4 in and 5 in × 3¼ in, etc		
Bengal and North Western	5 in × 3½ in	5 in × 3½ in	Will accept size agreed to by majority
Rohilkhand and Kumaon	Not stated		Concurs with view that label and holders used by broad gauge railways should be uniform the size used by the majority should be accepted
Bhavnagar Gondal Junagad Porbandar	Not stated		Agrees with the view that a uniform size of label should be adopted by railways of the same gauge
Bombay, Baroda and Central India	3¾ in × 3 in and 4 in × 3 in	4½ in × 3½ in	Will agree to 4½ in × 3½ in if other broad gauge railways do the same
East Coast	4 in × 3 in and 5 in × 3½ in		Will accept size agreed to by majority but prefer Oudh and Rohilkhand Railway's size
Eastern Bengal	4¾ in × 3 in	5 in × 3½ in	
East Indian	5 in × 3½ in, etc	5 in × 3½ in	Their holders will contain any labels not less than 4¾ in × 3 in
Great Indian Peninsula	4¾ in × 3½ in		Will adopt what Southern Mahratta Railway accept
Indian Midland	5 in × 3½ in	5 in × 3½ in	
Madras	4½ in × 3 in	5 in × 3½ in	
Morvi	4½ in × 3½ in		Will accept size agreed to by majority
Nizam's Guaranteed	4½ in × 5 in	4½ in × 5 in	Label holders 5 in × 4 in opening is 4½ in × 3 in
North Western	4½ in × 3½ in		Their rack will hold labels 4½ in × 3½ in the rack being made a little longer, 4¾ in × 3½ in Does not recommend any change
Oudh and Rohilkhand	5 in × 3½ in and 5 in × 3 in	5 in × 3½ in	See East Coast railway
South Indian	(1) 3¾ in × 3 in (old stock) (2) 5 in × 4 in (new stock)		Not interested except in interchanging with Southern Mahratta Railway who are in favour of a 5 in × 4 in card
Southern Mahratta		5 in × 4 in	See remarks by South Indian Railway and Great Indian Peninsula Railway

Pressed Steel Underframes — Subject 6-A

Memorandum by Mr J J Adler, Carriage and Wagon Superintendent Rajputana Malwa Railway dated Ajmere 27th November 1894.

[See Volume IV page 88, para 6]

Comparisons are made under three heads in both the carriage and the wagon under frames and bogies, Weight Cost, and Strength

38 6" Carriage Underframe and Bogies

Built up Underframes and Bogies, Drawings Nos 1718 and 1720, Consulting Engineer

Pressed Frames and Bogies, do do 1920 and 1921 ditto

1st Weight

Actual Weights

No	Description of parts	Built up Rolled Sections		Pressed Steel Sections	
		Pounds	Tons	Pounds	Tons
1	Underframe and ironwork	3 808	1 7	3 538	1 58
1	Set buffers and side chains	576	0 25	576	0 25
2	Bogies with ironwork	2 425	1 08	1 665	3 74
4	Pairs wheels and axles	3 924	1 75	3 924	1 75
8	Pressed steel axle boxes and brasses ..	328	0 14	328	0·15
	Bearing and supplementary springs complete	672	0·30	69*	3 31

Difference in favour of Pressed Steel 1,010 lb = 0 45 tons

The weight of 3 808 lb in underframes includes 202 lb total weight of strengthening the sole bars in built up frame

The difference in bogies calls for special remarks and extra tests for which see statement under the head of Remarks

2nd Cost

Actual Cost of 38 6" Metre gauge Underframes and Bogies

	Sterling cost F O B England						Cost in Rupees delivered at Ajmere					
	Built up			Pressed			Built up			Pressed		
							R = 14 757d			R = 15 425d		
	£	s	d	£	s	d	Rs	a	p	Rs	a	p
Underframes and ironwork ..	30	19	11	35	0	9	549	1	5	579	14	4
2 Bogies and ironwork	32	0	8	29	16	0	550	4	0	476	8	8
Total .	63	0	7	64	16	9	1,099	5	5	1 056	7	0

Pressed Steel Underframes — Subject 6 A

The frames were supplied at different periods at currency rates and different rates for freight The actual sterling and rupee rates are given

It will be seen from above that the built up underframes are the cheapest by £4 0 10

The built up bogies and ironwork however, cost £2 4s 8d more than the pressed ones, thus making a total difference in favour of built up underframe and bogies of £1 16 2

From this must be deducted the cost of supplying short trusses to built up underframes Rs 29

3rd, Strength

Test of 38' 6" Carriage Underframes

The frames were tested by being placed upon trestles at the bogie centres, with packings under the centre and side friction plates The load (cast iron) was equally distributed in each case over the whole frame The actual weight of the body loaded was 9 2 tons The test loads were 9 tons and 11 tons

The built up frame before testing had an upward camber of $\frac{1}{2}$" after the 11 ton test load it had a downward camber of $\frac{3}{4}$" at centre, making a total deflection of $1\frac{1}{4}$" This was deemed too elastic, and was therefore strengthened by short truss rods After this it had a downward camber with 11 ton load of $\frac{1}{16}$", total deflection being $\frac{1}{2}$"

The pressed frame was straight before testing After the 11 ton load it had $\frac{13}{16}$" downward camber

	BUILT UP FRAME	PRESSED FRAME
	Camber in whole length Inches at centre	Camber in whole length Inches at centre
Light or unloaded before testing	$\frac{7}{16}$ up	Straight
With 9 tons	Straight	$\frac{1}{2}$ down
With 11 tons	$\frac{1}{16}$ down	$\frac{13}{16}$ down
Total deflection	$\frac{1}{2}$	$\frac{13}{16}$
Permanent set	*Nil*	*Nil*

The 11 ton load remained upon the frames 2 days, making no difference in the deflection

It is noteworthy that the deep portion in centre of built up sole bar (8' long × 14" deep) did not deflect, whereas the deep portion in centre of pressed sole bar (8 long × 16" deep) deflected $\frac{1}{8}$", notwithstanding the extra depth. This was no doubt due to the flange springing under the tensional and compressive strains

Pressed Steel Underframes — Subject 6-A

Test of Bogie Trucks

Each bogie frame was laid upon the face of one of its sole bars It was packed underneath, and the bottom sole weighted to keep it firm The test loads were suspended at the axle guard centres of the top sole bar, supported now by the cross bars directly upon the centre of the wheel on each side and upon each bogie the test representing what blow the sole bars would withstand from the wheels upon entering sharp curves or crossings After testing up to 6 cwt at each centre the pressed frame had $\frac{1}{16}$' permanent set It was therefore deemed unadvisable to put any further load upon it, the deflection with 6 cwt load being as follows —

The built up truck had $\frac{1}{16}$ deflection at top of axle guard
and $\frac{1}{8}$" , at bottom of axle guard

Permanent set, *Nil*

The pressed truck had $\frac{1}{8}$" deflection at top of guard
and $\frac{1}{2}$" ,, at bottom of guard

Permanent set $\frac{1}{16}$

There is a difference of 760 lb weight and £2 4s 8d cost in favour of the pressed truck This difference is largely due to design The test shows the built up truck to be the more durable

The pressed sole bars being of $\frac{1}{4}$ plate are certainly weak I would recommend their being made at least $\frac{5}{16}$ or $\frac{3}{8}$ thick in future orders

Covered Goods Bogie Wagons, 36 feet long

Built up underframe and bogie truck, Drawings Nos 1725 and 1729 Consulting Engineer
Pressed underframe and bogie trucks, ,, 1925 and 1928 , ,,

Comparisons made under three heads as before, Weight, Cost and Strength

1st Weight

No	Description of parts	Built up		Pressed Steel	
		Pounds	Tons	Pounds	Tons
1	Underframe and body complete	8015	3 58	6 894	3 07
1	Set buffers complete	460	0 21	460	0 21
2	Bogies with iron work	1 647	0 73	1 162	0 52
4	Pairs wheels and axles	3 924	1 75	3 924	1 75
8	Axle boxes and brasses	328	0 15	328	0 15
8	Bearing springs	560	0 25	120	0 05
	Total	14 934	6 67	12,888	5 75
	Carrying Capacities	38 826	17 33	40 872	18 25

Difference favouring pressed steel = 2 046 lbs = 0 92 tons

The difference in bogies is referred to under the head of 'Remarks' at the end of this paper

Pressed Steel Underframes — Subject 6 A

2nd, Cost

Number	Description	Sterling cost F O B England						Cost in Rupees delivered at Ajmere					
		Built up			Pressed			Built up			Pressed		
								R = 14 757d			R = 15 125d		
		£	s	d	£	s	d	Rs	a	p	Rs	a.	p
1	Wagon underframe	36	6	4	36	4	6	645	1	4	598	0	8
2	Bogie trucks and ironwork	10	14	1	27	14	1	190	2	10	438	2	3
1	Set buffer gear	8	9	1	8	16	3	143	13	8	140	14	8
1	Set body and ironwork	40	10	3	43	6	2	777	11	1	729	8	10
	Total	95	19	9	116	1	0	1,756	12	11	1 906	10	5

The difference in the currency rates is accounted for by the fact that they were supplied at different periods The actual sterling and rupee rates are given There is a small difference of *1s 10d* only in favour of the pressed underframe In the bogie trucks there is a difference of *£17* in favour of the built up

3rd Strength

Test of 26 0" wagon underframes

Both frames, with the body rivetted up complete in each case were placed upon trestles at the bogie centres, and the test loads of 13 tons and 15 tons were equally distributed upon the floor of the wagon

There was no deflection in the sole bars of the built up frame the soles being quite straight before and after the application of the 15 ton load

The pressed frame sole bar deflected $\frac{5}{32}''$ at centre, and the ends dropped $\frac{1}{8}''$ with the 15 ton load

	Built up	Pressed
	Camber in whole length Inches at centre	Camber in whole length Inches at centre
Light, or unloaded before test	*Nil*	*Nil*
With 13 tons	"	$\frac{1}{16}$
15	"	$\frac{3}{32}$
Total deflection	"	$\frac{5}{32}$
Permanent set	"	$\frac{1}{16}$
Deflection of long studnals with 15 tons	$\frac{1}{16}$	$\frac{1}{8}$

The permanent set of $\frac{1}{16}''$ in pressed wagon may be due to this wagon not having been previously loaded

Pressed Steel Underframes — Subject 6-A

The built-up wagon had been in traffic four months, it, however, had no set in it According to gauge the ends of the pressed wagon dropped $\frac{1}{8}''$ with $\frac{1}{32}''$ permanent set. This was due to the bottom flange being out of square and being bent upwards owing to the weight resting upon the outer edge

The soles of the pressed wagon are certainly weak in the centre under the doorway.

The designs of the bogie trucks are not directly comparable, the built-up trucks being of a heavier design Some of the difference in the total weight is due to this, the difference in bearing springs accounting for 440 lb

	lb
Laminated bearing springs, built up bogies	560
Spiral " " pressed	120
	440

The headstocks provided in the built-up trucks add greatly to their durability No comparative tests were possible between these bogies, the built-up ones being the more durable, and the two cost £17 less than the pressed trucks.

BOGIES — SUBJECT 6.B. — ADLER'S PATENT BOGIE

Memorandum by Mr J J Adler, Carriage and Wagon Superintendent, Rajputana Malwa Railway, dated Ajmere, 5th September 1894

With reference to resolutions passed by the Committee of Locomotive and Carriage Superintendents in 1891, 1892 and 1893 at Ajmere, Lahore and Madras, respectively, on the subject of bogies, I submit the following tracings showing four different types of Adler's patent Bogie both for the metre and English gauge —

Bogie in use on the Lancashire and Yorkshire Railway, English gauge (*See plate XLVII*),

Do in use on the Belfast and Northern Counties Railway, Irish gauge.

Do. in use on the Rajputana-Malwa Railway, Metre gauge

Proposed Carriage Bogie Truck, Metre Gauge, as applied to Fox's Pressed frame. (*See plate XLVII*).

Two of these types show bogies in built up material and two in pressed steel All four show Adler's method of obtaining easy and steady running in carriages on bogies. With a view to describe the principle clearly and briefly, the type of bogie for the 4′ 8½″ gauge running upon the Lancashire and Yorkshire Railway in England is dwelt upon. It will be seen from the drawing (*Plate XLVII*) that there are two noticeable deviations from the conventional pattern.

Firstly,—The method of supporting the carriage on the bogie frame. In the present type of bogies with elliptical springs between body and swing bolster, the fact of introducing springs between top and bottom beam causes, from the deflection of the springs, an oscillating action which is not stopped by the bottom bolster being underhung on swing links

In Adler's bogie the bottom bolster or spring beam is practically dispensed with, and in its place there are bolted under the ends of the bolster, steel or iron bars of channel section, 8″ × 4″ × ⅜″, the ends of which are set down in order to provide room for the suspension links attached to the ends of the channel bars and to brackets rivetted to the bogie frame inside the sole bars

Compound India rubber springs are placed at both ends of the suspension links, the one at the lower end in the channel of the bar, the other on the bracket mentioned above.

The weight of the carriage body is thus distributed between the top and bottom springs to facilitate adjustment of weight the suspension links are connected to screwed eyebolts passing through the springs

The centres of the suspension links are 2′ 5″ apart longitudinally, being about 12″ more than with the ordinary type of bogie.

The carriage body rides on the bogie bolster on the usual central pivot casting and two side rubbing plates, care being taken that there is a good bearing on both plates, and not the $\frac{1}{16}$″ play that is sometimes erroneously allowed to occur

Bogies — Subject 6-B.

It will be observed that the carriage, being thus rigidly, so to speak, connected to the bolster, is entirely underhung the plane of connection between carriage and bogie truck being that through the lower ends of the suspension links procuring a condition of stable equilibrium

It is claimed that these arrangements entirely obviate or materially lessen end-pitching and rolling, and have the effect of producing a state of steadiness and quiet seldom attained in railway carriages

Secondly,—The arrangement in combination with the laminated steel springs, of the floating beams or equalisers made of steel or iron channel bars, $6 \times 3 \times \frac{1}{2}$

The weight of the carriage and bogie truck is supported by eight brackets rivetted to the outside of the sole bars, four of which, at the end of the sole bars, transfer the weight direct to the outer ends of the laminated springs by means of hangers passing through India rubber springs to the top side of the floating channel beam, which in turn transfers the weight through India rubber springs situated in the channel to the inner ends of the laminated steel springs by means of hangers, which are screwed to facilitate adjustment of weight

The beams are made as long as possible, the object being to get the inner bearing brackets as far apart as possible and close to the wheel centres, as this arrangement also tends to prevent pitching of the bogie frame

The main bearing springs are made of seven plates, $3'' \times \frac{1}{2}''$ with 5 0″ span

They are longer than those generally used and are found to give better results for bogie as well as for four or six wheeled carriages

It will be seen that the shocks from the rail pass through many insulating springs, thus preventing the vibration arising from rail joints, crossings, etc, being imparted to the body of the carriage, and ensuring quiet as well as steady running

The experimental carriage described above was tried by running at speeds up to 70 miles per hour, and the Locomotive and Carriage Superintendent, Mr F. Attock, expressed himself well satisfied with the result, the carriage having now been in running fully 12 months. The company have ordered six more carriages to make up a complete train with this type of bogie

Two other carriages are in running upon the Belfast and Northern Counties Railway in Ireland When Mr Malcolm (the Locomotive and Carriage Superintendent of that line) tried these bogies, they were loosely coupled at the end of a train and ran $4\frac{1}{4}$ miles in 4 minutes and even under these unusual conditions ran with great steadiness Eight more carriages have been ordered by this company

The London and North-Western Railway of England are also experimenting with these bogies, and I hope to receive from them a full report of the result before the Committee assembles at Calcutta during December next

It may be further remarked that the bogies under the Agent's Metre Gauge Saloon Carriage on the Rajputana-Malwa Railway have been altered, and the method described above applied This carriage now runs very stead[illegible]

In add[illegible] , making three noticeable devia[illegible] [illegible], viz —The swing links are hung with an angle [illegible] towards the centre at the bottom Practical experiments with the bogies shewn on the diagram, (*Plate XLVIII*) upon sharp curves, have confirmed this

Bogies. — Subject 6 B.

principle. To this, and the system of hanging upon top and bottom rubbers, is due $\frac{1}{2}''$ extra superelevation $\frac{3}{8}''$ to the former and $\frac{1}{8}''$ to the latter.

The conventional practice is to convey the weight direct from the bolster to the crossbars, for them to convey through the soles to the springs This, it is acknowledged, allows the reiterated knocks and bumps of bad roads, rail-joints, etc., to accumulate before the springs retaliate or assert themselves, whereas the rubbers in this system react or retaliate at once.

It will be seen from the following calculations that the link on inside of the curve is carrying the greater weight, causing it to fall and take the bolster in the direction of its fall. The curve taken is the maximum allowed for metre gauge, *viz*, 573 feet.

The coach in figure 1, plate XLVIII, is the new standard with floor level 3′ 1″, figure 2 is the old standard with floor level, 2′ 9½″, above rail

In the following calculations the weights of both types are taken as being the same —

$a = \begin{cases} \text{Angle of vertical centre of coach on curve} & = 6^\circ \\ \text{The 4'' super-elevation (max for 573')} & = 1 \text{ in } 10 \text{ nearly} \end{cases}$

$x_1 =$ Height of centre of gravity of loaded coach above rail, fig 1 = 4′ 3″

$x_2 =$ „ „ „ „ fig 2 = 3′ 11″

$y_1 =$ Height of bogie bolster top above rail level = fig 1 = 2′ 0¼″

$y_2 =$ „ „ „ „ = fig. 2 = 1′ 8¼″

$$\text{Sin } a\,(x_1 - y_1) = b_1 = 2\ 796$$
$$\text{Sin } a\,(x_2 - y_2) = b_2 = 2\ 796$$
b_1 and b_2 are similar take b

This brings the weight on bogie bolster b'' out of centre causing the rubbers on each side to carry unequal weights, the greater weight being on the inside of the curve.

If L = Length between centre of bearing blocks = 3′ 6′.

$$\frac{(\frac{1}{2}L + b)\ W}{L} = C = \text{Weight on inside 4 rubbers} = 64\ 58 \text{ cwts}$$

$$\frac{(\frac{1}{2}L - b)\ W}{L} = D = \text{Weight on outside 4 rubbers} = 49\ 42 \text{ cwts.}$$

Deflection of rubbers with C = .. $\frac{13}{64}$

„ „ „ D = . $\frac{9}{64}$

Difference = .. $\frac{1}{16}$.

The weight being upon two sets of rubbers, top and bottom, this must be multiplied by 2 making the super-elevation due to centre of gravity lying inside of curve at bogie centre = $\frac{1}{8}''$.

Add to this the amount due to the links travelling 1″ inwards from normal position = ... $\frac{3}{8}''$.

Total extra super-elevation = ... $\frac{1}{2}''$*

* This does not take account of the effect of centrifugal force, but is intended to show that even if the speed slightly exceeds that for which the super-elevation of the rails is calculated, the line of resultant pressure will still fall inside the rail centre line, the object being to keep this line of pressure to one side to prevent rolling —J J A

SPRINGS, BUFFER AND DRAW — SUBJECT 6-D. ABSTRACT OF CORRESPONDENCE

Copy of Circular letter No 4457 H, dated Howrah, 16th July 1894 from R. Pearce, Esq, Carriage and Wagon Superintendent, East Indian Railway, to all Members of the Committee.

The East Indian Railway have had a large percentage of breakages with the steel draw and buffer springs sent out, and I beg to hand you enclosed copies of the correspondence on this matter which has taken place between Mr Sandiford (our Chairman) and myself

I send you enclosed diagram of the springs used on the North Western Railway, together with diagrams Nos 1 to 4 of those in use on the East Indian Railway,* and propose to bring this subject up for discussion at the next conference meeting in December 1894, with a view to arrive at some conclusion, our experience warrants, as to the best form and material to be used for these springs

I shall feel obliged if you will at your early convenience favor me with your views on the subject and send me a diagram with particulars of the form of springs you would propose

On receipt of replies, I will endeavor to embody in a concise form the opinion of all members of our Committee (5 ft 6 in and metre gauge), with a view to facilitate discussion at next meeting

Copy of letter No 4358-H, dated Howrah 15th June 1894 from R Pearce Esq, to C Sandiford, Esq, Locomotive and Carriage Superintendent, North Western Railway

The following is an extract from a demi official letter received from the Consulting Engineer's Office in England in regard to breakages of steel draw springs, of which we have had so large a proportion —

"I have been going into the question of your draw bar spring failures I think it is clear that these failures are due to three causes

"(1) The want of a stop to prevent the spring going right home There can be no doubt it would add greatly to the life of the spring if it was stopped at least ½ from home This is specially the case with irregular sections

"(2) The draw bar is too short having been arranged for rubber, and there is not room to get in a proper spring

"(3) The springs are made of too high a tensile steel in the efforts of the steel makers to force a small spring to do the work of a large one This really results from (2)

* These are included in the diagrams given on pages 175 and 177 8

Springs, Buffer and Draw. — Subject 6-D.

I send you herewith a tracing of the steel draw spring adopted when rubber was given up. We have had other patterns since, but none of them stand.

The springs sent out to us have never had a chance of getting "home." they simply jam themselves before doing so. I send you a sample to look at.

Will you oblige by letting me have your experience with steel springs, and send me a tracing of what you consider the best pattern to adopt both for draw and buffer.

I think it is a matter that might well be taken up at next conference meeting, and on hearing from you I will write each Broad and Metre Gauge Locomotive and Carriage Superintendent and ask for drawings and opinions, and will then embody the whole and send up to Secretary.

We did very much better with *good* rubber it was only when bad was sent out, the cry came against it It must be good rubber and a good price paid for it.

Our steel draw springs now coming out, made by Messrs Turton Brothers and Matthews, only cost *2s 2d* (two shillings and two pence) each in England, and Rs. 1-13 6 in India.

Copy of reply from C Sandiford, Esq , to R. Pearce, Esq , Carriage and Wagon Superintendent, East Indian Railway, No 702 M S , dated Lahore, 23rd June 1894

I am much obliged for your No 4358-H of the 15th instant, and in reply beg to state that we have no springs exactly like either of those on your tracing

We however got out 100 volutes, like the large spring, on trial 2½ years ago (they are 8¼″ × 5¼″ 1⅞″ × hole), but up to the present none of these have broken perhaps it is due to the stop preventing more than 3¼″ buff We have none of the smaller springs

From one time to another I dare say we have had 60 to 70 different patterns. These were three years ago reduced to 32, and I have now reduced the number to those on the accompanying tracing,* of these volutes 9½″ × 6¼″, × 2¼″, weighing 34 lbs, give the best results They can be used for buffers or draw bars

The spirals 4¾″ × 5¼″ × 2¼″ hole, weighing 10 lbs, also stand well

The larger spirals for buffers do worst the breakage is very heavy

I quite agree with you the subject is a very important one, and with our yearly increasing loads, the draw and buffing springs are subject to constant work of a very much heavier nature than formerly, and to meet it better, stronger and heavier springs are wanted

As you say rubber (good stuff, not composition of sorts) did very well, but rubber is not to be had, certainly not at the price paid, and as it is so capable of adulteration, one has small trust in it.

Were I designing stock for a new road, I would have no more than four patterns of so many, but on a Railway like the North Western Railway, with articles of various patterns, it is not possible yet a while.

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* These are shown in diagrams on page 175.

Springs, Buffer and Draw — Subject 6-D

Copy of Circular letter No 212 Con, dated Howrah, 3rd August 1894, from R Pearce, Esq, Representative, Carriage and Wagon Sub Committee, to all Members of the Committee

In continuation of my No. 4457-H of 16th July 1894, I now beg to hand you enclosed blue print of volute steel buffer and draw springs* sent out for the East Indian Railway Company in the year 1866, which must have been in work for about 25 years They have only been lately taken out of wagons, and I have had them re-tempered, with the result as shown in the diagrams of tests

The price paid for these springs was very much higher than that now being paid, and it would be interesting to have an analysis of the old steel in comparison with the steel of the springs now supplied, and in this view I am addressing Sir Alexander Rendel and Son in the matter, sending them two of the old springs

Abstract of replies received

Mr Ryles Locomotive and Carriage Superintendent, Bengal and North Western Railway

There is no question the springs mentioned in letter No 212 of 3rd August 1894 are of exceptional quality, and it would pay all railways to obtain new supplies like them, but has doubts about getting them as Spencer and Co, like others do not make such steel now but no doubt would if a demand was set up

Sends tracings of the standard springs used, and no fault to find with them

Mr Rhind, Locomotive and Carriage Superintendent, Bengal Nagpur Railway

Regrets that his Company has suffered considerably in the matter of unsuitable springs and so far no satisfactory design has yet been supplied Sends ferrotypes of springs A and B tried, and failures frequent C only lately supplied, and not in a position to say how this will turn out

Of opinion that volute form of springs is best, but not likely to give satisfaction unless good material is insisted upon and paid for

Mr Winmill Locomotive and Carriage Superintendent, Oudh and Rohilkhand Railway

Has recently received draw and buffer springs of volute type and experienced difficulty The springs in being compressed never got fairly home without either being overstrained or breaking, thereby causing heavy renewals, and decided to use "spiral" form as being stronger and more regularly elastic

The increased loads and heavier types of vehicle caused him to design and indent for the spiral spring shown on Drawing No 1955 applies to draw bars and 18" buffers, and so far promises to be an excellent spring Diagram of test shows that it is regularly elastic, compressing 1½" to every 20 cwt till home.

Not in use very long, but thinks it quite safe to supersede the volute spring.

Regarding rubber, does not recommend it for this country.

* In diagram on page 178.

Springs, Buffer and Draw — Subject 6-D

Mr Cardew, Locomotive and Carriage Superintendent, Burma State Railway

It is not clearly stated whether complaint refers to both buffer and draw springs Remarks of Carriage and Wagon Superintendent, East Indian Railway, appears to refer to volute springs, as he does not see how spiral springs can jam If volutes are referred to this must be buffer springs as sketches do not show any draw springs. Finds it difficult to understand reference

Is quite of Sir A M Rendel s opinion that all troubles arise from there being no stops for the springs The only springs broken on Burma State Railway are the old class of volute having no stops There are occasionally pulls inside out, the draw bar nut and washer coming right through bringing the inner coil with it The springs are weak for the present loads, but scarcely weaker than springs in use with stops, and which never get torn asunder

Thinks the remarks about jamming must refer to volute springs Had the draw bars stops on them the springs would never get the length of jamming By jamming he understands, not merely the binding of the spring coils one against the other by internal frictional resistance, but more or less permanent set owing to metal being strained beyond limits of elasticity Never finds a spring to jam until the limit of elasticity has been passed

Greatly prefers spiral springs to volute because they are self stopping and there is far less internal resistance from friction In the damp climate of Burma volute springs suffer badly from rust, which greatly increases the resistance and goes on to say "On the metre gauge, however, where we have adopted W R S *Jones system of a flexible buffer* and draw bars, we are generally obliged to use volute springs in order to obtain the necessary transverse stiffness In his compound type where he employs a rubber annular pad, pressed on by a flanged casing in which the buffer bar slides to furnish the transverse resistance to the bar being deflected from the centre line of the vehicle, the thrust springs may be of any form In his simple arrangement, where the thrust springs have to do double duty by providing the transverse stiffness, spiral springs do not do well being far too lively so that the buffer lacking *transverse stiffness* vibrates with the every movement of the vehicle In the compound type, however (which is only applied to coaching stock), I now use nothing but spiral springs and find that they are more sensitive owing to the absence of internal friction accumulated dirt, rust, etc , so that jerks in starting and stopping are quite unknown

Quite agrees that good rubber (which has to be paid for, not the muck called rubber which is often sent to us) is quite *satisfactory for springs Further rubber springs have an* advantage not possessed by any steel springs, so far as he knows, in that they have a decreasing ratio of flexibility under an uniformly increasing load

The scales of deflection shown on the drawings of rubber springs sent show this plainly, while the scales on the steel springs show that their ratio of flexibility is practically uniform

The only method of getting a decreasing ratio of flexibility with steel springs with which I am acquainted is to put two together on the same bar on opposite sides of the headstock as we do on the metre gauge in Jones system In some correspondence (see Appendix A) with Mr *Gutersloh of the* Rajputana Malwa railway lately he suggested a return to the bad old practice of simple thrust springs to act as both buffer and draw I replied to him as per copy of letter attached, which will sufficiently explain itself With the adoption of double thrust springs compressed against each other for about half the stroke provi

(that is to say, ½, the total stroke provided) and fitted on Jones' system, with sockets or casings, it is possible to do without guides for your buffer and draw bars, which then float on the two springs without either wear or tear. Mr W R S Jones told me he believed it would pay to adopt the system on the broad gauge, as the price of springs nowadays is scarcely more than that of guides, while all wear and tear of both bars and guides would be saved as we find to be the case on the metre gauge.

Mr Jameson, Locomotive and Carriage Superintendent, Eastern Bengal State Railway

Sends diagram of springs in use The spiral springs, class A, have done fairly well, while the percentage of breakages of the volute springs in the C class buffer and draw springs is too high

The B class volute has stood well, but while of a heavier description than the other springs of this class, it also has a buffer of 3½" only

A principal cause of the breakage is no doubt a want of a stop, and the absence of this admits of the spring when driven home jamming, especially when in use some time, and rusty

There is rubber and rubber and so there is steel and steel. The former is going out of use as the Home authorities will not pay the price for good stuff and the cheaper article is generally rubbish In regard to steel, probably the makers aim at too high a tensile strength

The whole subject should be discussed at next meeting

Mr Wedderburn, Officiating Locomotive and Carriage Superintendent,
Bhavnagar Gondal Junagarh Porbandar Railway

Has not the slightest doubt that causes of breakage given in East Indian Railway Carriage and Wagon Superintendent's letter to Locomotive and Carriage Superintendent, North Western Railway, are the principal ones, and would add another—insufficient clearance between the coils

Sends ferro of types in use, and breakages have been practically ' nil '

Mr Adler, Carriage and Wagon Superintendent Rajputana Malwa Railway, Metre gauge

For years past this railway has had to meet a very heavy expenditure in the up keep of volute springs in use with the metre gauge buffer gear

Sends ferro of types of springs in use.

Resistance of five tons per 3 inch deflection, and if the steel these springs are made of prove of good quality, the volute spring question as regards the Rajputana Malwa *railway may* be considered to be fairly met

Volute springs of good quality only should be supplied and as few patterns as possible

Springs, Buffer and Draw — Subject 6-D

Has been obliged to abandon the re tempering of volute springs.

Calls attention to a new spring patented by Platts and Turton, sends particulars (see Appendix B)

Mr Phipps, Locomotive and Carriage Superintendent Madras Railway

Sends diagram of springs in use on the Madras railway, with the exception of springs made to Sections B and C, done fairly well

The engine buffer helical springs, Figure D, as well as the spiral springs made to Section A (Timmis' patent) have been universally very satisfactory In a few cases the volute springs, Figure E, have given trouble owing to bad tempering and bad material, while the spiral springs to Sections B and C have, for the same reason, broken right and left

Practically given up the use of India rubber, as it has been found to perish in a very short time and give us endless trouble

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Appendix A.

Copy of letter No. $\frac{6398}{\text{L C }75}$, dated Insein, 28th May 1894 from the Locomotive and Carriage Superintendent, Burma State Railway, to F N Gutersloh, Esq, Locomotive Superintendent, Rajputana Malwa Railway, Ajmere

I am extremely obliged to you for your letters of the 10th February and 21st April last I am very glad to hear that your new buffing arrangement is likely to be a success At the same time I am quite unable to agree with you that there is anything wrong or objectionable in using buff and draw springs having a certain amount of initial compression on them The residual stroke of the springs is ample for our metre gauge requirements, being 2½″ both ways either in or out

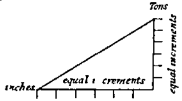
1 One of the objects of initial compression is, as you state, to get the necessary elastic resistance for rendering the buffers transversely flexible, but another most important object is to make the buffers much less liable to sudden jerks in starting and to sudden recoil after stopping

2 When two springs are opposed to one another on the same draw bar with the headstock between, and each with a certain amount of initial compression, it results in their rate of compressibility commencing at zero and proceeding, not by equal increments of pressure per unit of length compressed (as for an uncompressed spring), but by increasing increments of pressure for each unit of length. This greatly helps avoidance of jerks and recoil

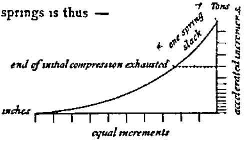
3 In the old days, which you must very well recollect, when we used only single combined buff and draw springs (doing double duty) the shocks in starting and stopping were very bad indeed This was far more due to the use of single springs than to the old slack buffers (as we had no screw couplings) It was only during 1888-89, when I was employed on the South Indian railway, that this fact impressed itself upon me There they had nothing but single springs, and the whole of the slack between buffers was taken up either by Crighton s wooden discs (which have been used there for many years) or by Turton's and other forms of slack gathering buffers, yet, in spite of there being very little slack between buffers, the jerks in starting and the recoil in stopping were so bad that it was quite impossible to sleep through them.

Springs, Buffer and Draw — Subject 6 D

4 Whatever you do stick to two springs or you will do more harm than good The Americans (I see from papers I take in) are just commencing to adopt the same view as Jones did 14 years ago namely that initial and opposed compression between buff and draw springs is absolutely necessary for easy starting and stopping The diagram of an uncompressed spring is thus —



while that for two oppositely compressed springs is thus —



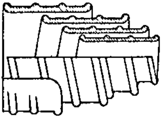
Appendix B

Extract from the Ironmonger s letter dated 20th January 1894 page 134

Turton patent ribbed section volute spring

This spring is also worthy of remark, it having been brought out with a view to reducing the weight of material and at the same time increasing the elasticity and the weight carrying power of the spring and reducing the friction of the spring to a minimum

It will be observed that when driven home tightly the bearing of the spring can only be on the ribbed portions, instead of on the whole width of the bar, which obviously reduces the friction



It is claimed that with this spring a saving is effected in material of 30 per cent over the ordinary plain bar, together with a gain of from 35 to 40 per cent extra strength

From actual tests of the spring made with an ordinary plain bar section $3\frac{1}{2} \times \frac{5}{16}$ inch, weighing 22 lbs a weight carrying power is obtained of $2\frac{1}{2}$ tons when $\frac{1}{8}$ inch from home, whereas with a volute spring made of this patent ribbed section $3\frac{1}{2} \times \frac{1}{4}$ inch (in the web), weighing $17\frac{1}{2}$ lbs the weight carrying power obtained is 4 tons when $\frac{1}{4}$ inch from home

From this it will be seen that the ribbed section spring possesses an enormous advantage over the ordinary section namely $1\frac{1}{2}$ tons more carrying power, with $4\frac{1}{2}$ lbs saving of material per spring It is patent from this that the new inventions should take the market, looking at them from the points of economy and durability

Springs, Buffer and Draw — Subject 6 D.

Memorandum by Mr Pearce, Carriage and Wagon Superintendent, East Indian Railway, on the breakages of draw and buffer springs submitted at the Conference of Locomotive and Carriage Superintendents, Calcutta Meeting, December 1894

It will, I think, be well to trace back for some years the history and working of the several kinds of draw and buffer springs on the East Indian railway

Up to the year 1874 the springs in use were the old laminated form, in many cases acting both for draw and buffer, and others only as buffer with a volute draw spring

The weight of this description of draw and buffer gear was about 16 cwt, costing about Rs 225 per vehicle

With the increasing loads of goods trains and mixed trains, the springs were not strong enough for the duty required, the draw bars at starting being too much drawn out; consequent rebounding of buffers to the destruction of stock and discomfort in case of passengers It was therefore decided to adopt some other kind of spring, and India rubber took the place of steel

In 1880 a question arose as to continuing the supply of rubber springs at what was considered a high price, and the then Carriage and Wagon Superintendent wrote in April 1880 as follows —

"As to durability, we have the India rubber springs running for six years as good as ever no failures (in one or two accidents the draw bars and nuts were pulled through cross bars, headstock, springs, and all else)

"The comfort to passengers in heavy mixed trains is great formerly passengers and goods together meant almost driving the passengers off their seats at starting and proportionate injury to stock.

' With 600 tons goods trains it is absolute to select strong buffering and draw gear.

"After many trials of laminated volute spiral and all the springs combined I am of opinion for true economy we cannot do better than continue as we are'

So long as the quality of the rubber sent out to India continued good, the working of the springs was all that could be desired, and I think this will be borne out by those members of the Committee who were supplied with the first lot of rubber springs.

In 1880, owing to competition, and well known manufacturers binding themselves and guaranteeing to supply rubber of the special quality required subject to any chemical or other tests, at about half the price previously paid, the authorities in England had no option but to accept in good faith the tenders received, and with what disastrous results to our working expenses we all know The failures were so bad and so numerous that the use of rubber was prohibited

The rubber springs supplied were to all outward appearance good and stood the tests imposed one chemical analysis actually showing that they were better in quality than the springs originally supplied and for a time the matter was not understood, until found out that the manufacturers in England had been mixing old with new rubber, thus enabling them to supply the springs at a very low cost It is unnecessary to go further into this, sufficient to say that, the failures being so serious, it was decided in England in 1880 to go back to the use of steel springs, with up to date as bad results as the failures of the rubber This is the experience on the East Indian railway, and from the opinions forwarded to me by several members it has been the same on other lines

Springs, Buffer and Draw—Subject 6 D

The following facts are before us in regard to the use of draw and buffer springs on the East Indian railway —

(*a*) High priced laminated draw and buffer and volute draw springs	Satisfactory as regards material but abandoned on account of cost and weight and being unequal to the duty required
(*b*) Superior quality rubber springs *Supplied from 1874 to 1880*	Excellent results in every respect In use from nine to ten years (specimens of these will be shown at meeting), and draw springs in use for fourteen years past, taken out of vehicles, also specimens of India rubber, springs which have been running under a bogie carriage for 13 years 11 months
(*c*) Low priced inferior rubber or mixed quality Supplied from 1880 to 1889	Absolutely bad and failed in every respect
(*d*) Low priced steel springs. Supplied from 1890 to date.	I have given in a drawing the results of working of these springs as bad as the inferior rubber springs under (*c*)

From the opinions received from several members of Committee and for which I have to express my thanks I gather that the same trouble in regard to steel springs has been experienced on their railways It appears to be generally agreed that the cause of failure has been bad quality of material and bad workmanship and that the price of the springs supplied is too low to insure good quality In these opinions I entirely concur

A stop has been recommended to prevent the spring being drawn to the utmost extent of its elasticity It is therefore necessary to enquire what this stop is intended to do I hope in the following remarks I may not be understood as advocating or believing that the ultimate shock should come on the spring I regret to record that I have had experience in the last two years of what a stop is likely to do The inferior steel springs have provided an effectual stop in jamming themselves or breaking before getting near home, and as a consequence we have been pulling on the cross bars as yet I do not know nor can I estimate, the cost of repairs required vehicles are coming in daily with their bars bent This is exactlly what will occur when we have (if we do have) a stop to our springs It only means that with a stop the faulty spring will be considered good and its failure only found out when *the framework is not strong enough to stand the strain*

In my opinion we do not require a stop it would merely aid bad workmanship and bad material What we do want is a spring of such quality and strength that will stand the pressure required without being overstrained or broken With our tight screw coupled vehicles there should not be difficulty in making such a spring, and only in collision or extraordinary shunting would there be a chance of the spring being injured or giving way, *whether the spring is made of steel or rubber the quality must be beyond suspicion*

We have just received from England some iron wagons and a stop to the draw bar spring has been supplied in the shape of a wrought iron socket (shown at meeting) similar to a buffer case, weighing 28 lbs each or, deducting the present base plate, 16 lbs = 24 lbs per wagon The cost of these has been invoiced at 8 shillings and 6 pence per wagon, and to my mind, apart from the weight to be carried about, I would rather have seen the price put into the springs

As drawn attention to by Mr Cardew, whose opinion on this subject is most valuable, the advantage the rubber springs have over steel is that they have a decreasing ratio of flexibility under an uniformly increasing load, whereas the steel spring is practically

uniform. Consideration will show how this must affect the careful starting of a train, the steel being drawn out at least double as much as rubber, and it is for this reason I do not consider that the old spring of 20 years, good as it is (diagram of which I have sent and specimen of which will be shown to you), is comparable with the best rubber

I am merely remarking on facts All I ask for is the supply of good material with workmanship, and only record here that my opinion of good rubber is, that it is infinitely superior to any steel springs we have ever been supplied with But even with this experience, I would not go so far as to recommend that "all our eggs be put into one basket." We have of late dearly bought our experience of doing this but I think on the evidence before us we are justified in recommending that a further trial of the best rubber should be made against the best steel springs obtainable, and let each stand on its own merits We must bear in mind that our experience of the steel springs latterly sent out has been as bad as the worst rubber supplied

Summarising, I beg to record the following opinions —

1 —That good rubber has held its own against any steel springs

2 —That the price paid latterly for springs, either rubber or steel is not sufficient to ensure good material and workmanship

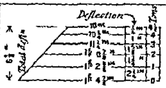
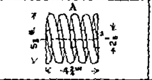
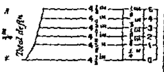
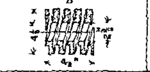
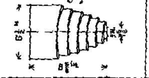
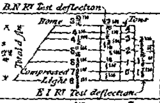
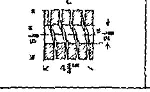
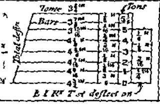
3 —That too much reliance is placed on the chemical test for steel as was done with the mixed rubber

4 —That the steel springs supplied have not been of sufficient weight

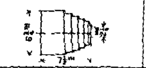
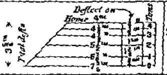
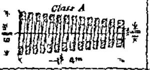
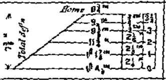
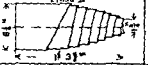
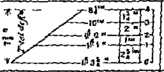
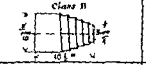
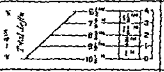
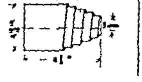
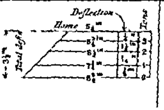
I have submitted diagrams of all the springs used by the East Indian railway, draw and buffer, also diagrams of spring in use by the North Western railway Eastern Bengal State railway, Bengal Nagpur railway, Oudh and Rohilkhand railway, Bengal and North-Western railway, Bhavnagar Gondal Junagarh Porbandar railway, Madras railway, and Great Indian Peninsula railway for consideration of the Committee, and hope *some conclusion may be come to and a resolution recorded*

Springs, Buffer and Draw—Subject 6 D.

B. N. Ry.

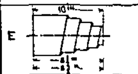
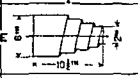
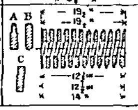
Description of Springs	Material	Weight lbs	Cost in England	Cost in India	PATTERN	Diagram of Test.	MAKERS NAME		Percentage of Breakages	Remarks by & Carr S
Buffer, spiral	Steel	39	s d 9 0		A 		Turton Brothers & Matthews			
Draw spiral	Steel	17	3 9		A 		Turton Brothers & Matthews			Fa lure of A & B been fre
Buffer helical	Steel				B 					
Draw spiral	Steel				B 					
Buffer, volute	Steel	27	b 0		C 		George Turton, Platts & Co			Only latel use canno how w ll out s of op that form of s is the best, good mai must be ins upon and for
Draw spiral	Steel	15 5	4 11½		C 		George Turton Platts & Co			

E B. S. Ry.

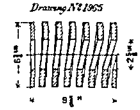
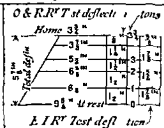
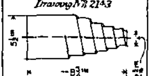
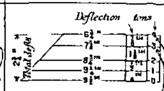
Description of Springs	Material	Weight lbs	Cost in England	Cost in India	PATTERN	Diagram of Test.	MAKERS NAME		Percentage of Breakages	Remarks
Draw, volute	Steel	29	s d 4 0½	R a p 4 8 0			J Spencer & Sons			
Buffer, spiral	Steel	36	6 10½	6-10 0	Class A 		J Spencer & Sons			A Class These have do fa rly well
Buffer volute	Steel	48	4 0	6 0-0	Class A 		J Spencer & Sons			Only a few on t but w th good sults
Buffer volute	Steel	37	5 3	3 12 9	Class B 		Brown Bayley D xon & Co			B Class. Stood well only buff of 3½ inch and is heavier th other springs
B ffer volute	Steel	20	2 10½	2 8 9	Class C 		J Spencer & Sons			C Class Percentage b eakages h gh Pr nc p cause of b ea ages no dou want of a st and absence th s when driv home adm ts jo m ng

Springs, Buffer and Draw.—Subject 6 D.

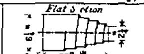
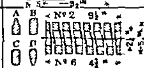
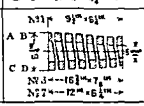
M R Co

Description of Springs	Material	Weight, lbs.	Cost in England	Cost in India	Pattern	Diagram of Test	Makers Name	Percentage of Breakages	Remarks by Loco. & Carr Supdt
Draw, volute	Steel	27 5 23 18	s d 2 9 to 9 1½	R a p 1 11 1 to 5 9 8		10ⁱⁿ Deflection 1¼ⁱⁿ per ton 8¼ⁱⁿ do. 1¼ⁱⁿ do. 6¾ⁱⁿ do. ¾ⁱⁿ do.	Turton Cammell and Ibbotson generally done well; Brown's have failed		Have had trouble owing to bad tempering and bad material
Buffer, volute	Steel	25	2 9 to 9 1½	1 11 1 to 5 9 8		Deflection 3⅜ⁱⁿ per ton			Ditto
Buffer helical	Steel	27	4 3 to 5 3	2 5 7 to 3 1 8		Deflection 1¼ⁱⁿ per ton			Universally very satisfactory
Buffer spiral	Steel	30A 34B 26A 31C 23A	21 0 9 6 21 0 9 6 21 0	11 12 5 5 2 11 11 12 5 5 2 11 11 12 5		19½ⁱⁿ Taper deflection 2ⁱⁿ per ton 19½ⁱⁿ Parallel do. 2ⁱⁿ do 12¼ⁱⁿ Taper do 1⅜ⁱⁿ do. 12¼ⁱⁿ Parallel do 1⅜ⁱⁿ do. 14ⁱⁿ Taper do. 1⅛ⁱⁿ do.			Section A (Timm's) universally very satisfactory B & C gave trouble owing to bad tempering and bad material and springs broke right and left

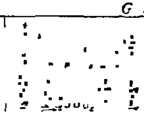
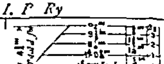
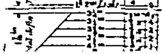
O. & R. Ry.

Description of Springs	Material	Weight, lbs.	Cost in England	Cost in India	Pattern	Diagram of Test	Remarks
Draw and 18 inch. Buffer spiral	Steel	26	6 1½		Drawing No 1965 		Have experienced difficulties with draw bar and buffer springs of volute type The springs on being compressed never get fairly home without being overstrained or breaking Decided in consequence to use spiral form as being stronger and more regularly elastic as per Drawing No 1965 Does for draw bars and 18" buffer and promises to be an excellent spring Not running very long but can safely say will supersede the Volute spring
Draw	Steel	21			Drawing No 2143  Generally 9½ⁱⁿ	 Approximate from 60 cwt upwards on account of the coils binding plate to plate	Old pattern volute spring now being discarded Test of spring compressed to 6¾ with 80 cwt and 7¾ with 60 cwt but these results are unreliable Spring loses its elasticity when pressed to 50 cwt. coils binding against each other causing at 60 cwt the coils to stick and slip while load was being increased the spring appearing rigid Behaviour of springs unsatisfactory and large number of breakages

N W Ry.

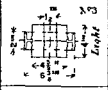
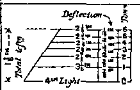
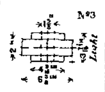
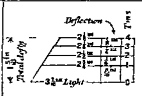
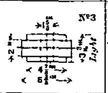
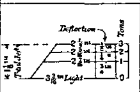
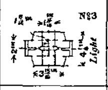
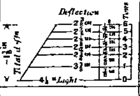
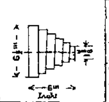
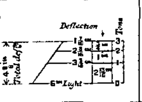
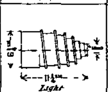
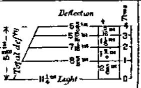
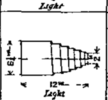
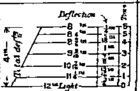
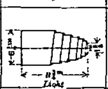
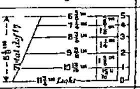
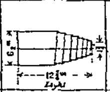
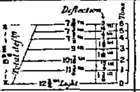
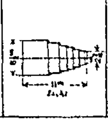
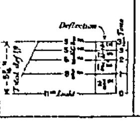
Description of Springs	Material	Weight, lbs.	Cost in England	Cost in India	Pattern	Diagram of Test	Makers Name	Percentage of Breakages	Remarks
Draw, volute	Steel	No. 5 34			Flat Section 				
Draw, spiral	Steel	No 2 25 No. 6, 10							
Buffer spiral	Steel	No. 1, 24 No. 3, 44 No 7, 31							

G I. P Ry

Description of Springs	Material	Weight, lbs.	Cost in England	Cost in India	Pattern	Diagram of Test	Makers Name	Percentage of Breakages	Remarks
Buffer	Steel								Standard buffer and draw springs unable to say with certainty makers, and not in a position to give prices, and no record
Draw	Steel								

Springs, Buffer and Draw.—Subject 6 D.

E. I. Ry.

	No in use and Indent No.	Description of Springs and year	Material.	Weight, lbs.	Cost in England	Cost in India.	PATTERN	Diagram of Test.	MAKERS' NAME	Time in use when taken out	Percentage of Breakages	Remarks by Carr & Wagon Supdt
					s d	R a p.						
1		Buffer, 1877.	India Rubber.	5 75	10 2	5-15-0			G Spencer and Co.	9 to 10 years	...	9 to 10 years in use specimen will be shewn at meeting
2	7000	Old Buffer, 1877 From C. G. No 1876	India Rubber	5 75	10 2	5 15-0			G Spencer and Co.	9 8 years.	...	Do. do.
3		Old Buffer, 1877 From C G No 878.	India Rubber.	5 75	10 2	5 15-0			G Spencer and Co.	11'3 years.	...	Do. do
4		Buffer, conical	India Rubber		10 2				G Spencer and Co	...	...	Test good.
5	Indt. 304/1250	Buffer, helical, 1890.	Steel.	10 68	3 5½	2-0-2			Turton Bros and Matthews	2 years.	40'72	Running about 24 months, 509 broken.
6	Indt. 304/625	Buffer, volute, 1890	Steel	27 68	10 3	6 4 5			Turton Bros and Matthews	2 years.	12 01	Running about 24 months, 76 broken
7	Indt. 333/1200	Buffer, volute, 1891	Steel	38 31	5 3	3-9-0			J Brown and Co	1 1 years.	2 75	Running about 14 months, 33 broken
8	Indt. 375/1000	Buffer, volute, 1893	Steel	41 87	6 0	5 4-0			J Spencer and Sons	...	..	Running about 17 months
9	Indt. 396/1000	Buffer, volute, 1894.	Steel	47	9 3	8 13-0			Turton Bros. and Matthews.	...	..	Just received in October 1894
10	Indt./110	1855 Buffer, volute, Retempered, 1894.	Steel	35	23 6	-			T. Turton and Sons.	20 to 25 years.	...	This spring was supplied in the year 1856 and was taken out of a wagon in July 1874 and must have been at work from 20 to 25 years. After being retempered stood the test given in diagram, specimen shewn.

Axle boxes in pressed and cast steel—Subject C

Committee of Locomotive and Carriage Superintendents

R.C. R.R.
1772
11-5-96

DEAR SIR,

In the Index of Volume VI of the Proceedings the item—

Axle boxes in pressed and cast steel page 179

has been accidentally omitted Kindly correct this error

Yours truly,

F WOLLEY-DOD,

Secretary to the Committee

It is well known that the largest percentage of fractures to cast iron axle boxes occur by the dust-guard shield plate at the back of the box being forced violently against the dust-guard collar of the axle in shunting operations, resulting in the side of the axle box behind the axle guards being broken, that is to say, the tendency of the shock is to tear the side of the box away from the crown and bottom This no doubt explains the cause of the fractures in the pressed steel boxes, the sides in their case cannot be fractured, but the shock is conveyed to and expends itself on the corner where it is weakened as described

In other respects this axle box has given satisfaction, there being no large number of cases of heating as compared with other designs of boxes in use, or any other general objection, the opening in the front of the box might be reduced by raising the lower lip as shown in the sketch so as to increase the packing reservoir I note that they soon become dirty from leakage of oil at the face plate and accumulated dust, the use of a swing or hinged face plate and the omission of the oil hole in the face plate would also be an improvement, it would prevent needless oiling when from want of time the bolts and nuts cannot be removed and replaced for examination of the state of the packing Train examiners habitually oil all boxes, many of them already replete with oil, for want of a ready means of examination, and the provision of a hole in the face plate encourages them not to go to the trouble of removing it, even when there is ample time and opportunity.

Axle-boxes in pressed and cast steel — Subject 7 C

The opinion has often been expressed that with the use of so thin a sheet metal the plate at the bottom of the axle guard grooves would soon get worn through by the friction of the axle guard against the box I have examined many of the boxes in use but must confess to not being able to detect any indication that this is likely to occur, beyond a slight polishing of the bottom of the grooves, there seems no indication of any reduction of the thickness of the metal It is however, the case that with cast iron boxes the inner edges and also the face of the legs of the axle guards do wear away to a considerable extent in the course of years and all the sooner if care is not exercised in keeping the axle-guards square and true but in this case it is the chilled skin of cast iron working against malleable iron whereas with the pressed steel boxes both surfaces coming in contact are equally soft and malleable, so that little actual friction and consequent wear result

I would not, however advocate an extension of the use of these boxes unless the defects pointed out can be overcome The greater part of the loss entailed by damage to a vehicle in an axle box during the busy season when every available vehicle is a factor in the possible earnings lies in the loss incurred by the vehicle being laid up and if the pressed steel boxes, as they are now, are to fail and require replacement or repairs, such as described, there can be no economy in further adopting their use

The cast steel axle boxes, plate L, were indented for under Indent No $\frac{671\ 15}{124}$ of 1892 and were begun to be put into work in July 1893 In using them to replace damaged cast iron axle boxes I decided to give them as general a trial as possible, and accordingly fitted a few to each class of stock to begin with, reserving future renewals mainly for goods and coal vehicles

Two hundred and eighty of the cast steel boxes are now in use, the greater number being in work since the date of receipt in the country, during which time I have not had a single complaint against them nor have they shown any defect whatever, and no cases of fracture have occurred even amongst those fitted to the coal wagons used on the Sanctoria branch, where damages to axle boxes are, as is to be expected most frequent

This is a most satisfactory result to have to report and goes far to compensate for their high first cost, which I note was 32 shillings in England and the issue rate in Nagpur Rs 25 8 0, but when it is considered that these good results are obtained with complete immunity from fracture, I think that the first cost is after all but a small matter

Since 1889 up to 30th June of this year the records show that 3 325 cast iron axle boxes have had to be renewed owing to fracture, the records are not, however, quite complete some months of the early days of the broad gauge having been lost nor does this number include those replaced during the time the line was under construction for which the capital of the railway was debited so that I am quite safe in saying that the total debited to Revenue could not have been less than 3 325 or a half yearly average of 302 out of a total wagon stock of 3 535 this at Rs 8 per axle box without brass bearing, which is about the issue rate in Nagpur, and the average rate of those manufactured in the shops, totals up to Rs 26 600

As already pointed out, this by no means represents the total loss incurred, loss of earnings in vehicles being laid up, for it is at the very time they are most required that breakages are the most frequent The loss by haulage to shops in many cases must be added, as well as loss of oil and the cost of extra staff to carry out repairs all these causes contribute to recommend very strongly the adoption of any axle box that will tend to their reduction even if the first cost is high and this is pre eminently the case with the cast steel boxes which have so far shown themselves free from liability to fracture under any working conditions

In the design of the axle box I would recommend a few minor alterations as shown in plate L, figs 1 and 2

Axle boxes in pressed and cast steel — Subject 7 C

As in the case of the pressed steel box, the lower lip of the front opening might be raised a little I would also advocate an increase of depth, etc, as shown in the figure, these alterations would admit of a 4½ inch or 4 inch diameter journal being used as might be necessary, the present internal width being ample this would be a great advantage, doing away with the increased width between axle guard legs at present considered necessary when a 4½ inch diameter journal is used with a cast iron axle box

The swing face plate provided in these boxes at my suggestion requires a few words of comment The number in use as yet is not, as will be seen, great, and although there are also a few cast iron boxes with a similar design of face plate the total of both is not great enough to give rise to any remark from the examining staff for or against them, still I can safely say from my own personal practical knowledge of the disadvantages of the, in India, usual type of bolted face plate, that a swing or hinged face plate, for the reasons already referred to in my remarks on the pressed steel axle-box, would be economical and advantageous

The objection made to this type of face plate is a sound one, viz that it affords an easy means of theft of the lubricating packing, but this applies more to the northern parts of India, where the winters are cold and natives will abstract the oily packing for use as fuel to provide warmth In this and the more southern parts of the country the necessity of fuel for warmth is not so great, and for cooking purposes oily waste is a very bad substitute for fuel as its odour pervades the food and makes it unpalatable

I have only had one case of the removal of the packing from the cast steel axle boxes, the damage done to the box only served to show the advantage of their use, in so far that the dust guard washerway, which is cast solid with box was at the opening left for the insertion of the leather washer warped and twisted, but this was soon put to right by the blacksmith and the box put into work again as good as ever.

Admitting however as I am quite prepared to do the necessity for some provision against this contingency, it is surely not impossible to design a special nut for the studs that fixes a swing or hinged face plate and so prevent the lubricating packing being tampered with, such as for instance, a round nut only capable of being slackened back (it should not be possible to remove the nuts from the stud altogether so as to prevent their loss) by means of a G shaped spanner or in any other way thought advisable the provision *of a few special spanners to the staff would very soon be compensated for by economy in* oil when the interior of the axle box could be readily examined and the face plate refixed in its place, it would also do away with those numerous markings on the sole bars, called examination marks, placed there for the information of the staff to indicate when next the face plates should be removed for examination of the lubricating packing With the use of a hinged or swing face plate the necessity for repacking the box would be evident to the examiners, and by more frequent examination fewer hot boxes would, I am sure, be the much to be desired result

In conclusion I would state that when at home in 1892 these axle boxes were then under manufacture by Messrs D Drummond & Sons Govan At the request of our Consulting Engineer in London I visited the works of this firm, where I saw one of the boxes tested by crushing the sides in, until they met, with repeated blows of a forehammer, the box being held on a solid iron block Under this severe test the metal merely fractured in no case did any part of the box break away At my instigation the box was set at an angle with the back opening upwards and the lower side resting in the axle-guard grooves on the edge of the iron block, the side of the dust guard washerway and part of the box that is usually broken away when fractures occur from violent shunting was struck several times with the forehammer with the object of ascertaining if this part *could be fractured or broken, but no further impression was made than the abrasion of* the metal produced by the blows

Axle boxes in pressed and cast steel — Subject 7-C

From my experience of them I have formed a decidedly favourable opinion of the cast steel box and I am sure that with more of them in use a decided reduction of our expenditure in replacement of damaged axle-boxes must result, and being practically unbreakable they will barring extreme cases of accident, outlast more than one vehicle In finally deciding on adopting their more extensive use I think their first cost should not be allowed to weigh in any way against them, the more general use of them will no doubt lessen this somewhat, and their advantages of being capable of being used with both a 4 inch and 4½ inch journal, while retaining the standard axle guard of 6¾ inch as well as their reduced weight as compared with the cast iron axle box, *viz.* 74½ lb against 112¾ lb, should be given great weight in considering the question

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Copy of letter No 10457, dated 30th June 1893 from the Locomotive and Carriage Superintendent, to the Agent and Chief Engineer, Bengal Nagpur Railway

I beg to send you enclosed in a box one of the 100 patent pressed steel axle-boxes supplied under Indent No 50 L. of 1890, the crown plate of which has fractured and allowed the brass bearing to have play in the box As the defect seems one that could be easily remedied in future axle boxes of this type, and as doubtless our Consulting Engineer would with this object in view, bring it to the notice of the manufacturers I would ask that it be sent for his inspection

The axle box is one of four fitted to covered goods wagon 2236 in January of this year, out of which three have fractured in a similar manner In other respects these boxes give no trouble and seem satisfactory

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Copy of a report by Sir A M Rendel Consulting Engineer to the Bengal Nagpur Railway, dated London, 24th October 1894

I have your letter of the 24th September forwarding an extract from the Agent's letter No 136 regarding the trials made of the axle boxes sent out for experimental purposes in compliance with Indents Nos 50 L and $\frac{67\ L-15}{136}$

The greatest difficulty was experienced in complying with the indent for stamped steel boxes The manufacture of boxes under this patent had only just commenced, and even now is in a more or less experimental stage I am not surprised therefore that a few defects have come to notice in actual working

I will now deal with these defects in detail —

(1) The casting forming the crown of the box which Mr Rhind found to be rather weak has been replaced by a forging in all recent designs The box was not pressed over the casting as the Locomotive Superintendent appears to think, but the box was heated and the casting shrunk in after the box was made

(2) I anticipated difficulty in welding in the bottoms of these boxes, and special attention was paid to the inspection of this portion of the work Each box was tested and several had to be rejected for defective welds These defects are most difficult to detect and it speaks well for the inspection that so few have been found in actual working

(3) The most serious defect so far brought to notice and fortunately the simplest to remedy, is that boxes have cracked at the back along the corners formed by the sides and crown

Axle boxes in pressed and cast steel — Subject 7 C

I expected the axle guard would cut through the groove in the box and to prevent this I have for some time insisted on all pressed steel boxes being made of $\frac{5}{16}$th inch plate instead of $\frac{1}{4}$ inch as the makers wished I think the experiments on your line have not extended over a sufficiently long period to test this It is well known that cast iron axle boxes wear their guards The inference is that the wear, which in the case of cast iron boxes is confined to the axle guards, would in the case of pressed steel boxes be divided between the box and guard The groove in the pressed steel box is shorter than in the cast iron one, besides being less true, and the box is therefore more liable to tilt and the wear is doubly liable to be localised

I am glad Messrs Drummond s boxes are satisfactory they passed every test we could *devise here The manufacture of these boxes was quite a new thing and there was some* difficulty in hitting upon a light and strong des gn of box which would suit the material

I have investigated the question of the 'Flexible Cast Iron box which Mr Wynne stated had given satisfaction I obtained a box from the makers, which they stated is an exact duplicate of those supplied to your Company This box is made of the same material as the Drummond box 'Flexible Cast Iron is merely a trade name

The material consists of 25 per cent of good scrap steel and 75 per cent hæmatite pig melted together The castings are run direct from the cupola and then packed in boxes with hæmatite ore and exposed to a high temperature for five or six days This material is called 'steel' in the Birmingham District where it is largely used for castings, as it is more easily moulded than steel and is much stronger than cast iron The value of the material depends on the annealing being properly done, and it is by no means easy to check this at reasonable cost

The weight and present cost of the various classes of boxes in use on your line complete with brasses, compare as follows —

	Weight in lbs	Cost Rs	A	P
Cast Iron	113 75	22	9	0
Drummond	66 5	32	0	0
Flexible Cast Iron	86 87	35	0	0
Stamped Steel	68 04	31	1	0
Pressed Steel (Fox)	78 5	30	3	0

The price paid for the 'Flexible Cast Iron box includes the cost of two patents namely that of the dust guard and oil hole cover which form no part of the box itself If we used the ordinary dust guard and methods of lubrication which, in my opinion are quite as good as the patent kinds the cost of the box would be 5 shillings less The weight of this box can also easily be reduced to 72 lb

There will be little to choose in weight between the various steel boxes and their relative value will thus depend on price and strength alone The so called cast steel box has so far proved the best, and I am glad of this as it involves no patent The material is in common use, and no special plant being required for it, a demand for b

made of it has only to be established to bring the price down to little more than that of cast iron, and by exporting a small quantity of hæmatite iron they might even be made in India

The figures which Mr Rhind gives are not sufficiently complete to fix the life of a cast iron box on your railway Failures are always more plentiful on a new line, and the defective boxes are bound to get weeded out at an early period I therefore doubt if a sufficiently good case has been made against cast iron to justify its wholesale condemnation, but if the price of the "Cast Steel" box can be reduced considerably, as I anticipate it can then the general adoption of this material for boxes is perhaps desirable

CLASSIFICATION OF ROLLING-STOCK — SUBJECT 9-I

The form proposed by Mr R Pearce was considered at the meeting, certain alterations were agreed to, and the following general principles decided on —

That all rolling-stock, both coaching and goods vehicles, should be divided primarily into classes, as shown in annexed form, and that as far as possible all vehicles should be shown under these classes only.

That each class should be subdivided into types, in the manner shown in the annexed form, the actual types differing somewhat on different railways

For goods vehicles, it was at the meeting decided to show both the length *and width* of the body, but when an attempt was made to draw out the form in accordance with this, it was found that it would be cumbrous, pending further consideration, width of body has been omitted, and length only, which is the most important dimension, entered

Platform wagons, and wagons with sides, either high or low, are all classed as "open wagons," being different types of this class

It is perhaps a question whether the name of the class "Coal hoppers" should not be altered to "Hopper wagons," as more comprehensive, hopper wagons being occasionally used for articles other than coal

It is also for consideration whether it is desirable to distinguish coaching vehicles fitted with gas from those not so fitted.

In accordance with the Resolution adopted on page 80, the form is now printed and published for further opinion

F W.-D

Statement of Rolling stock — Subject 9 I

Statement of rolling-s

CLASS	TYPE: Description *	TYPE: Number of wheels	TYPE: Average tare	Total number of each type	ACCOMMODATION IN EACH VEHICLE: First: Passengers	First: Troops	Second: Passengers	Second: Troops	Intermediate: Passengers	Intermediate: Troops	Th: Passengers
	1	3	4	5	6	7	8	9	0		
Coaching Vehicles		No	Tons	No	No	No	No	No	No	No	No
1 Saloons	*Viceregal Bogie*	8	22½	2	—	—	—	—	—	—	—
	Dining and cooking saloons	8	18	2	—	—	—	—	—	—	—
	Reserved family	4	10	23	9	—	—	—	—	—	—
2 First Class	*Lateral seats with bath rooms*	4	9½	71	12	12	—	—	—	—	—
3 Second Class	*Lateral seats with bath rooms*	4	9	84	—	—	24	24	—	—	—
	Do	4	10½	1	—	—	24	24	—	—	—
4 Intermediate Class	*6 Compartments*	4	9	26	—	—	—	—	60	36	—
	5 Do	4	9	47	—	—	—	—	50	30	—
5 Third Class	*6 Compartments*	4	9	632	—	—	—	—	—	—	60
	Double story	4	7½	1	—	—	—	—	—	—	85
	Bogie	8	23½	2	—	—	—	—	—	—	180
	Ambulance with latrine	4	9	52	—	—	—	—	—	—	57
6 Composite	*I and II lateral seats with bath rooms*	4	9	29	6	6	12	12	—	—	—
	Do do	4	9½	25	6	6	12	12	—	—	—
	I and II transverse seats without bath rooms	4	9½	15	12	12	16	12	—	—	—
	Do do	4	11	1	12	12	16	16	—	—	—
	I II and Intermediate bogie	8	—	—	16	12	25	15	40	24	—
	Intermediate and III	4	9¾	24	—	—	—	—	60	36	50
	III and brake	8	—	—	—	—	—	—	—	—	100
	III and ½ postal	4	10¼	24	—	—	—	—	—	—	30
7 Postal vans	*Full*	4	11	22	—	—	—	—	—	—	—
	Carried over	—	—	083	—	—	—	—	—	—	—

* [illegible] bath room or [illegible] accommodation [illegible] separately

Statement of Rolling-stock — Subject 9-I.

for half-year ended 189 .

Number of each class fitted with vacuum brake or pipes.		Total stock authorised.	Total stock constructed against authorisations up to the last day of the previous half year	Additions to stock during the half year	Reduction of stock.	Total stock on the list at end of the half year.	Actual stock in running order on the last day of the half year.	REPAIRS AND RENEWALS.				Average number undergoing repairs and renewals at any one time	Condemnation during the half year
								Number of vehicles repaired during the half-year.	Number of vehicles renewed during the half year	Number of vehicles undergoing or awaiting repairs on the last day of the half year.	Number of vehicles undergoing or awaiting renewals on the last day of the half year		
14	15	16	17	18	19	20	21	22	23	24	25	26	27
B.	P.	No.	No	No.	No	No	No	No	No	No	No	No	No
4	—	4	4	—	—	4	4	3	—	—	—	—	—
1	21	23	23	—	—	23	23	49	—	—	—	2 79	—
44	16	71	83	—	12	71	60	169	—	11	—	14·64	—
35	16	85	94	—	9	85	84	211	—	1	—	13 04	—
29	6	73	70	3	—	73	69	52	—	4	—	4 04	—
68	13	(a)740	700	—	—	700	692	322	—	8	—	37 06	—
11	12	70	49	21	—	70	65	150	—	5	—	5·60	—
—	—	(b)9	—	—	—	—	—	—	—	—	—	—	—
—	—	14	14	—	—	14	14	—	—	—	—	—	—
—	—	(c)36	—	—	—	—	—	—	—	—	—	—	—
12	12	22	25	—	3	22	20	15	—	2	—	0	—
22	—	21	21	—	—	21	18	95	—	3			—
226	06	1,168	1 083	24	24	1,083	1,051	1,066	—	34			—

(a) Includes [illegible] bogies sanctioned under Resolution No. [illegible] of [illegible] but not yet erected.
(b) Sanctioned under Resolution No. [illegible] of [illegible] but not yet erected.
(c) Do. ditto. ditto. ditto.

Statement of Rolling stock — Subject 9 1

Statement of rolling-st

CLASS	TYPE: Description	TYPE: Number of wheels	TYPE: Average tare	Total number of each type	First: Passengers	First: Troops	Second: Passengers	Second: Troops	Intermediate: Passengers	Intermediate: Troops	Th[ird]: Passengers	
1	2	3	4	5	6	7	8	9	10	11	12	
		No	Tons	No	No	No	No	No	No	No	No.	
Coaching Vehicles —*continued*	*Brought forward*	—	—	1 083	—	—		—	—	—	—	
8 Carriage Trucks	*2 of 10 tons* *16 of 12 tons* *21 of 13 tons* *0 one carriage each*	4	6	39	—	—	—	—	—	—	—	—
9 Horse boxes	*6 horses or 4 tons*	4	$8\frac{1}{2}$	75	—	—	—	—	—	—	—	—
10 Luggage vans	*3 compartments, 10 tons*	4	8	21	—	—	—	—	—	—	—	—
11 Brake vans	*Passenger, 13 ton*	6	$14\frac{1}{2}$	30	—	—	—	—	—	—	—	—
	Passenger 10 ton	4	9	102	—	—	—	—	—	—	—	—
	Total coaching	—	—	1 350	—	—	—	—	—	—	—	—

Statement of Rolling-stock — Subject 9-I

for half-year ended 189 —(continued).

Number of each class fitted with vacuum brake or pipes.		Total stock authorised.	Total stock constructed against authorisations up to the last day of the previous ha f year	Additions to stock during the half year.	Reduction of stock.	Total stock on the list at end of the ha.f year	Actual stock in running order on the last day of the ha f year	REPAIRS AND RENEWALS.				A erage n mber undergoing repairs and renewals at any one time.	Condemnation during the ha f year
								N mber of vehicles repaired during the ha f-year	Number of vehic es renewed during the half-year	Number of vehicles under going or awa t ng repairs on the last day of the ha f year	Number of vehicles undergoing or awaiting renewals on the last day of the half year		
14	15	16	17	18	19	20	21	22	23	24	25	25	27
B	P.	No	No	No	No	No	No	No.	No	No	No.	No	No.
226	96	1 168	1 083	24	24	1 083	1 051	1 066	—	34	—	79 46	—
—	29	39	39	—	—	39	38	18	—	—	1	1 37	1
—	39	75	75	—	—	75	72	65	—	3	—	2·08	—
18	—	21	21	—	—	21	19	46	—	1	1	3·54	1
1	—	—	—	—	—	—	—	—	—	—	—	—	—
15	—	132	132	—	—	132	130	120	—	2	—	10·05	—
260	164	1,435	1,350	24	24	1,350	1,308	1,315	—		2	9/ 57	

Statement of Rolling-stock — Subject 9-I.

Statement of rolling-stock

CLASS	TYPE. Description	Number of wheels	Average tare	Total number of each type	First: Passengers	First: Troops	Second: Passengers	Second: Troops	Intermediate: Passengers	Intermediate: Troops	Third: Passengers	Third: Troops
1	2	3	4	5	6	7	8	9	10	11	12	13
Coaching Vehicles —*continued.*		No	Tons	No	No	No	No	No	No	No	No	No
	Brought forward...	—	—	1 083	—	—		—	—	—	—	—
8 Carriage Trucks	*2 of 10 tons* *16 of 12 tons* *21 of 13 tons* *Or one carriage each*	4	6	39	—	—	—	—	—	—	—	—
9 Horse boxes ...	*6 horses or 4 tons* ...	4	$8\frac{1}{2}$	75	—	—	—	—	—	—	—	—
10 Luggage vans	*3 compartments, 10 tons*	4	8	21	—	—	—	—	—	—	—	—
11. Brake vans	*Passenger, 13 ton* ..	6	$14\frac{1}{2}$	30	—	—	—	—	—	—	—	—
	Passenger, 10 ton ...	4	9	102	—	—	—	—	—	—	—	—
	Total coaching ...	—	—	1,350	—	—	—	—	—	—	—	—

Statement of Rolling-stock — Subject 9-I.

for half-year ended 189 —(continued).

Number of each class fitted with vacuum brake or pipes.		Total stock authorised.	Total stock constructed against authorisations up to the last day of the previous half year	Additions to stock during the half year.	Reduction of stock.	Total stock on the list at end of the half year.	Actual stock in running order on the last day of the half year	REPAIRS AND RENEWALS. Number of vehicles repaired during the half-year	Number of vehicles renewed during the half-year	Number of vehicles under going or awaiting repairs on the last day of the half year	Number of vehicles undergoing or awaiting renewals on the last day of the half year	Average number undergoing repairs and renewals at any one time.
14	15	16	17	18	19	20	21	22	23	24	25	26
B	P.	No	No	No	No	No	No	No	No	No	No	No
226	96	1,168	1 083	24	24	1 083	1,051	1,066	—	34	—	79 46
—	29	39	39	—	—	39	38	18	—	—	1	1 37
—	39	75	75	—	—	75	72	65	—	3	—	2·08
18	—	21	21	—	—	21	19	46	—	1	1	3 54
1	—	—	—	—	—	—	—	—	—	—	—	—
15	—	132	132	—	—	132	130	120	—	2	—	10·05
260	164	1,435	1,350	24	24	1 350	1,308	1,315	—	40		50

Statement of Rolling-stock — Subject 9-I.

Statement of rolling-sto

CLASS.	TYPE.				NUMBER OF VEHICLES WITH LOAD CAPACITY NOT							
	Description.	Number of wheels.	Average length of body.	Average tare	10 Tons	11 Tons	12 Tons	13 Tons	14 Tons	15 Tons.	16 Tons	17 Tons
1	2	3	4	5	6	7	8	9	10	11	12	13
Goods Vehicles		No	Ft In	Tons	No	No	No	No	No	No	No	No
1. Covered goods	*Wooden, baggage* ...	4	22 0	7	5	—	19	—	—	—	—	—
	*Wooden, Military** ...	4	18 0	$6\frac{3}{4}$	—	—	—	891	—	—	—	—
	*Iron, Military** ...	4	18 0	$7\frac{1}{4}$	—	—	—	102	—	—	—	—
	Iron, ordinary .	4	18 0	$6\frac{3}{4}$	—	—	—	2 920	—	—	—	—
	Wooden, ordinary . .	4	16 0	$5\frac{3}{4}$	345	—	—	1 645	—	2	—	—
		—	—	—	350	—	19	5 558	—	2	—	—
2. Open wagons	*Wooden, six wheeled*	6	22 0	$6\frac{3}{4}$	—	—	—	—	—	—	—	3
	Wooden, ordinary ...	4	21 0	7	—	—	—	—	—	—	—	2
	Do. do ...	4	19 3	$6\frac{1}{2}$	38	—	—	—	—	—	—	—
	Wooden, Military . .	4	19 3	$6\frac{1}{2}$	—	—	18	993	115	—	—	1
	Iron, Military . .	4	19 3	6	—	—	—	220	68	—	110	—
	Wooden, ordinary ...	4	18 0	$5\frac{3}{4}$	154	—	—	—	—	—	—	—
	Do, coal or coke .	4	18 0	6	—	3	—	—	—	—	—	—
	Do, ordinary ...	4	16 0	$4\frac{1}{4}$	84	—	—	—	—	—	—	—
	Do, dummy for cranes, with well	4	16 0	5	11	—	—	—	—	—	—	—
		—	—	—	287	3	18	1 213	184	—	110	6
3 Powder-vans	*Ordinary* ...	4	16 0	7	31	—	—	—	—	—	—	—
4. Timber trucks	*Iron with bolster* ...	—	—	—	—	—	—	—	—	—	—	—
	Wooden with bolster...	4	12 6	5	—	91	—	—	—	—	—	—
5 Coal hoppers	*Iron* ...	4	14 0	5	—	—	348	512	—	—	—	—
	Wooden ...	4	14 0	5	—	171	—	—	—	—	—	—
6 Cattle wagons	*Covered* ...	4	18 0	6	7	—	—	9	—	—	—	—
7. Sheep trucks	*200 sheep in 3 tiers*...	4	18 0	8	5	—	—	—	—	—	—	—
	Carried forward ...	—	—	—	680	265	385	7 29[illegible]	184	2	110	6

* To carry 8 horses or 10 ponies.

Statement of Rolling-stock — Subject 9-I.

for half-year ended 189 —(continued).

EXCEED.												REPAIRS AND RENEWALS.					
— Tons	— Tons.	Total Number.	Total tonnage or load capacity.	Number of each class fitted with vacuum brake or pipes.		Total stock authorised.	Total stock constructed against authorisations up to the last day of the previous half year.	Additions to stock during the half-year.	Reduction of stock	Total stock on the list at end of the half year	Actual stock in running order on the last day of the half year.	Number of vehicles repaired during the half year	Number of vehicles renewed during the half-year.	Number of vehicles undergoing or awaiting repairs on the last day of the half year.	Number of vehicles undergoing or awaiting renewals on the last day of the half year	Average number undergoing repairs and renewals at any one time	Condemnation during the half year.
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
No.	No	No	Tons	B.	P	No	No	No	No	No	No	No	No	No	No	No	No.
—	—	24	278	—	6	—	—	—	—	—	—	—	—	—	—	—	—
—	—	891	11,583	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	102	1,326	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	2,920	37,960	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	1 992	24 865	—	—	—	—	13	—	—	—	—	—	—	—	—	—
—	—	5 929	76 012	—	6	6,429(d)	5 916	—	—	5 916	5 669	3 538	—	229	71	147 20	—
—	—	3	51	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	2	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	38	380	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	1,127	14 749	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	399	5 589	—	—	500	—	—	—	—	—	—	—	—	—	—	—
—	—	154	1,540	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	3	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	84	840	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	11	110	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	1,821	23,326	—	—	2,321 (e)	1,786	35	—	1,821	1,789	750	110	20	12	160 07	—
—	—	31	310	—	—	31	31	—	—	31	31	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	91	1,001	—	—	91	99	—	8	91	86	—	—	5	—	—	—
— —	— —	1,031	12,713	—	—	1,031	1,058	—	27	1 031	1,004	365	—	27	—	57 85	—
—	—	16	187	—	—	16	16	—	—	16	16	—	—	—	—	—	—
—	—	5	50	—	—	5	5	—	—	5	5	—	—	—		—	—
—	—	8 924	113 591	—	6	9 924	8 911	48	35	8 924	8,547	4,653	110			53	—

(d) Includes 500 additional covered wagons sanctioned under Resolution No. [illegible] of [illegible] but not yet erected.
(e) { Includes 500 additional open wagons sanctioned under Resolution No. [illegible] of [illegible] but not yet erected.
Ditto 500 ditto ditto No. [illegible] of [illegible] ditto.

WORKING OF THE BRAKE — SUBJECT 11.

Enclosure to Secretary's letter No C. 96, dated 10th August 1894

Letter No 327 Stat, from the Director General of Railways, to the Secretary, Committee of Locomotive and Carriage Superintendents, dated Simla 21st July 1894.

I have the honour to forward herewith copy of Government of India, Public Works Department, No 22 R Stat, dated 22nd January 1894, relative to the results of the working of continuous automatic brakes on Indian railways during the 1st half of 1893, and to invite attention to the cases of delay due to failure of the material and machinery of the vacuum brake as shown in table II of the enclosure. In view of these failures, I would request the favour of your kindly obtaining the opinion of the members of the committee who are acquainted with the results of the actual working of the brakes in this country, as to whether the brake is working satisfactorily in India.

TABLE No. 1

Statement showing the Indian railways on which continuous automatic brakes were in use on the 30th June 1893, the description and number of rolling-stock, and the mileage run by trains fitted with the brakes

Railways (including branch lines worked)	Locomotives fitted.	Vehicles. Braked.	Vehicles. Piped.	Number of miles run by trains fitted.	Proportion per cent. Of vehicles piped or fitted on total.	Proportion per cent. Of mileage run by trains fitted on total train mileage
STANDARD GAUGE						
State lines worked by the State.						
North Western (state)	213	(a) 1 354	87	(b) 591 716	11 88	12·64
Oudh and Rohilkhand (state)	15	110	12	197 632	2 46	13 91
Eastern Bengal (state)	15	104	13	154 158	4 93	17 23
Line worked by guaranteed company						
Great Indian Peninsula	74	259	55	273,618	3 26	4 90
METRE GAUGE						
State line worked by company						
South Indian	16			...		

(a) [illegible] made over to the Mushkaf Bolan Railway
(b) Approximate

Automatic Vacuum Brake — Subject II.

TABLE No. II.

Stat [illegible] *1893, all cases in which the* [illegible] *to be brought into action, or*

1	2	3	4	5
Railway	Name or description of brakes which failed or caused delay in the instances specified in column 4.	Date of failure.	[illegible]	[illegible]
			STANDARD GAUGE, STATE LINES WORKED BY THE STATE	
North Western (state)	Vacuum Automatic	13th January 1893	(iii) Failure of material—4 down mail detained 40 min at Sohâwa, brake gearing having become disconnected in consequence of brass bar hanger having broken	
		22nd January 1893	(iii) Neglect of servants—3 up mail detained 6 min at Saharanpur, vacuum pipe in rear of train having been disconnected at last moment to shunt on a carriage, and pipe not having been replaced	
		1st February 1893	(iii) Failure of machinery—4 down mail delayed 3 min at Sarsawa, piston rod having jammed.	
		2nd February 1893	(iii) Failure of machinery—4 down mail detained 1 hr 58 min. at Begamabad, brake blocks of third class carriage No 1605 having jammed, in consequence all brake gearings had to be taken down. Brake pins were hard set, this accounts for the long delay	
		7th February 1893	(iii) Failure of machinery—6 down mail detained 5 min at Ladhowal releasing brake off wheels of front brake which were skidding	
		7th February 1893	(iii) Neglect of servants—5 min detention to 80 down goods owing to failure of driver to have his brakes taken up, thus rendering them inefficient	591,716*
		23rd February 1893	(iii) Failure of machinery—3 up mail detained 9 min brake shaft having broken where it had been badly welded.	
		[illegible]	[illegible]	
		26th March 1893	(iii) Neglect of servants. 5 min. lost by 3 up mail at Rajpura releasing vacuum brake of whole train, owing to a carriage without vacuum pipe, having been attached next front brake and carriage examiner not having been asked to release the vacuum	
		28th [illegible] 1893	[illegible] driver having omitted to have slack in brake blocks taken up No delay	
		4th April 1893	(iii) Failure of machinery—5 up mail delayed 9 min. at Ghaziabad, vacuum pipe blowing, and 10 min at Begamabad taking off vacuum brake.	

* Approximate.

Automatic Vacuum Brake — Subject 11

TABLE No II—*contd.*

Statement showing, for the six months ending 30th June 1893, all cases in which the continuous automatic brakes failed to act when required to be brought into action, or caused delay in the working of trains—contd

1	2	3	4	5
Railway	Name or description of brakes which failed or caused delay in the instances specified in column 4	Date of failure	Instances under the three following heads separately of— 1 Failure or partial failure to act when required in case of an accident to a train or a collision between trains being imminent 2 Failure or partial failure to act under ordinary circumstances to stop a train when required 3 Delay in the working of trains in consequence of defects in or improper action of the brake distinguishing whether they arise from neglect or inexperience of servants or failure of machinery or material	Number of miles run by trains fitted with each description of continuous automatic brake
			STANDARD GAUGE STATE LINES WORKED BY THE STATE	
North Western (State)—*contd*	Vacuum Automatic	7th June 1893	( ) Failure of machinery —4 down mail detained 10 min at Sarai Banjara releasing carriage brake of train	591 716*
		9th June 1893	( ) Failure of machinery —3 min detention to 4 down mail at Muzaffarnagar releasing vacuum brake of brake van	
Oudh and Rohilkhand (State)	Vacuum Automatic	11th February 1893	( ) Failure of material —Engine on No 2 down mail Lucknow to Fyzabad unable to maintain vacuum at Daryabad owing to rubber pipe leading to vacuum chamber having a hole burnt in it probably by fire from ash pan No delay	197,652
		26th May 1893	( ) Failure of material —3 min detention to No 1 up mail at mile 131 owing to pipe between tender and brake van being disconnected by striking the carcass of a bullock	
		5th June 1893	( ) Failure of material —No 1 up mail collided with a bullock cart at gate house No 256 mile 269 causing a detention of 26 min Connection between train pipe and engine cylinder being damaged, brake applied itself and stopped train	
Eastern Bengal (State)	Do		No failure or delay	154 158
			LINE WORKED BY GUARANTEED COMPANY	
Great Indian Peninsula	Do	10th January 1893	( ) Failure of material —4 min delay to 89 down passenger starting from Victoria terminus to fit new rubber washer owing to a defective washer of Clayton's coupling of postal composite 461 having caused a leak	275 618
		11th February 1893	( ) Neglect of servants —Driver unable to create vacuum owing to his having packed ejector disc of engine No 643 on 149 down in such a manner that the disc was not in contact with its seating 8 min delay at Lonavla withdrawing a portion of packing	
		16th February 1893	(1) Failure of material —5 min delay starting from Victoria terminus rubber pipe leading to cylinder of brake van No 1297 B type on 57 down found broken	
		17th February 1893	( ) Failure of material —8 min delay on journey after leaving Talegaon removing broken pipe and plugging up hole of rubber pipe leading to cylinder of brake van No 1297 B on 61 down	

* Approximate

Automatic Vacuum Brake — Subject 11

TABLE No II—*concld.*

Stat[illegible] *the* [illegible] *or*

1	2	3	4	5
Railway	Name or description of brakes which failed or caused delay in the instances specified in column 4	Date of failure	[illegible]	[illegible]
			STANDARD GAUGE LINE WORKED BY GUARANTEED COMPANY—*contd*	
Great Indian Peninsula —*contd*	Vacuum Automatic	[illegible]	[illegible] created necessary vacuum [illegible], 15' in rear brake as required by rules	
		[illegible]	[illegible]	
		15th May 1893	(i) Failure of material —Rubber coupling of engine No 640 on 57 down found defective 5 min delay at Victoria terminus waiting for washer to be renewed	275 618
		[illegible]	[illegible]	
		[illegible]	[illegible]	
		23rd June 1893	(ii) F[illegible]	

SOUTHERN MAHRATTA RAILWAY WORKSHOPS AT HUBLI — SUBJECT 15

Note by Mr C P Whitcombe Locomotive and Carriage Superintendent, Southern Mahratta Railway, dated Hubli, 3rd October 1894

Period of construction and arrangement of buildings

The construction of the Southern Mahratta Railway Workshops at Hubli was commenced in 1885 and finished in 1888 the relative positions of the several shops and of the General Stores building are illustrated in Plate LI

The total area of the ground occupied by the buildings and yards is nearly 34 acres.

Capacity with respect to mileage worked

The workshops as originally designed, were intended to serve 800 miles of railway and the extensions shown in dotted lines in Plate LI have become necessary owing to the extent of the system worked by the Company having increased to nearly double that length

Mileage statistics, 1894

The total length of line worked by the Southern Mahratta Railway Company on the 30th June 1894 was 1,536 miles the train mileage run during the 12 months ended on the same date was 3 190,635

Rolling stock

Particulars of rolling stock owned by the Company are as follows —

Locomotive stock			220
Coaching	Single unit	846	903
	Double	57	
Goods	Single ,	4 535	4 684
	Double ,	149	

Cost of buildings, permanent way, etc

The approximate expenditure on buildings, including also permanent way drainage, water supply, reservoir in connection with condensing engines and fencing amounts to Rs 15,12,000, the estimated cost of the extensions is Rs 1,95,000

Machinery and tools

A detailed list of the machinery with particulars of distribution to the several shops will be found in the appendix, the cost of each machine is shown separately and the aggregate cost of the miscellaneous tools allotted is entered separately against each shop The cost of sanctioned equipment amounts to Rs 9 30 456, the grand total, including provision for the requirements of the extensions, will probably amount to ten lakhs.

Southern Mahratta Railway Workshops — Subject 15

Location of Workshops at Hubli and remarks about Subsidiary Workshops.

Hubli was selected as the site of the Workshops owing to its central position with regard to the Southern Mahratta Railway proper, which extended between Poona Hotgi Bellary and Harihar There are subsidiary workshops at Bengalore built by the Mysore State for repairing and maintaining the rolling stock of the Mysore State Railway, the area occupied by the shops and yard is about 2½ acres, the expenditure incurred is Rs 1,15 000 on buildings, etc, and Rs 1,09 060 on machinery and tools, a complete list of which is attached Each large engine changing station has been supplied with one lathe, one shaping machine and one drilling machine, in addition to the usual equipment of tools in order to facilitate light repairs

Southern Mahratta Railway Workshops — Subject 15

Tools and Plant — Hubli Workshops

Item No.	DESCRIPTION	No	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
			Rs A P	Pence per rupee	
	I Machine and Fitting Shops				
1	Crane travelling flying cord $2\frac{1}{2}$ tons with guide wheels and gear complete	1	4 527 0 0	16 327	
2	Crane travelling hand 3 tons	1	2 763 0 0	16 327	
3	Engine all 8 H P vertical with boiler and shafting clutch gear complete	1	3 953 0 0	16 327	
4	Engines 12 H P portable	2	6 064 0 0		1 spare
5	Grindstones 6 × 8 with driving gear and 2 spare stones	2	2 066 0 0	16 205	
6	Lathe axle brass boring with 4 chucks and 2 steel boring bars	1	1 255 0 0	16 563	
7					
		1	3 0 6 0 0	17 262	
8	Lathe 6" centre 5 ft bed hand power	1	150 0 0		Purchased in India
9	Lathe double acting stud turning and screwing 6 centre	1	867 0 0	16 327	
10	Lathe heading and pointing 6 centre	1	897 0 0		Purchased in India
11	Lathe single geared 6" centre 5 ft 6 in bed	1	955 0 0	17 247	
12	Lathes self acting sliding and screw cutting 6 centre 5 ft 6 in bed	4	10 060 0 0	17 931	
13	Lathe screw cutting 7" centre 6 ft bed	1	675 0 0		From B K R.
14	Lathe screw cutting 8" centre 13 ft 6 in bed	1	2 093 0 0		Purchased in India
15	Lathe screw cutting $8\frac{1}{2}$ centre 10 ft bed	1	984 0 0		From B K R
16	Lathes self acting sliding and screw cutting 8 centres 8 ft beds	4	8 480 0 0	16 563 & 16 327	
17	Lathes self acting sliding and screw cutting 8" centres 9 ft beds	2	4 352 0 0	16 327	
18	Lathes additional parts for above	2	6 218 0 0	15 425	
19	Lathes 8" centres 5 ft beds brass finishing Cooper s patent	2	7 010 0 0	15 425	
20	*Lathes 8" centres 6 ft beds, brass* finishing Cooper s patent	3	11 600 0 0	15 425	
21	Lathe screw-cutting 10" centre	1	2 652 0 0		Purchased in India
22	Do. do do $19\frac{1}{2}$ ft bed	1	4 855 0 0		From B. K R
23	Lathes self acting sliding and screw cutting 10" centres 10 ft. beds	2	5 431 0 0	16 936 & 16 327	
	Carried over		90 933 0 0		

Southern Mahratta Railway Workshops — Subject 15.

Item No.	DESCRIPTION	No.	Amount.	Approximate rates of exchange at which prices of the machines have been calculated.	REMARKS
			Rs. A. P.	Pence per rupee	
	Brought forward ..		90,933 0 0		
	Machine and Fitting Shops— (*contd.*)				
24	Lathes, additional parts, consisting of fixed head stock, slide rest, face plate, chuck, countershaft and pulleys, for above	2	6,983 0 0	15 425	
25	Lathe, self-acting, sliding and screw-cutting, 10" centre, 30 ft bed ...	1	8,089 0 0	16 563	
26	Lathe, additional parts for above	1	3,213 0 0	15 425	
27	Lathe, hand, single geared, 10" centre, 9 ft. bed	1	1,618 0 0	16 205	
28	Lathes, self acting, sliding and screw-cutting, 12" centres, 12 ft. beds	2	6,797 0 0	16 563	
29	Lathes, 12" centres, additional parts, consisting of fast head stock, slide rest, chuck and countershaft, with brackets, complete .	2	5 220 0 0	14 891	
30	Lathe, self-acting, sliding and screw-cutting, 15" centre, 14 ft bed	1	4,711 0 0	16 563	
31	Lathe, self acting, sliding and screw-cutting, 18" centre, 15 ft. bed ..	1	7,763 0 0	16 327	
32	Lathe journal, with head stocks and two compound slide rests for turning journals of tender, carriage and wagon wheels up to 29" on tread	1	2,014 0 0	16 563	
33	Lathes, wheel, double face plate, suitable for wheels with a maximum diameter of 29" ..	3	18,369 0 0	16 563	
34	Lathes, wheel, double face plate, suitable for wheels with a maximum diameter of 54"	2	19,711 0 0	16 563	
35	Lathe, tyre boring, suitable for boring tyres 29" diameter on tread	1	10,216 0 0	14 757	
36	Lathe, tyre boring, suitable for boring tyres 54" diameter on tread	1			
37	Machine, drilling, hand	1	55 0 0	...	Purchased in India
38	Machines, drilling, bench, to drill holes, ⅛" to 1"	2	670 0 0		Ditto
39	Machines, drilling, vertical, tyre adapted for drilling holes up to 1½" diameter	3	5,096 0 0	17 247	
40	Machines drilling single geared, to drill holes 1¾" diameter 5" deep	2	4 062 0 0	17·247	
41	Machines, drilling single speed, to drill holes ¾" diameter 6" deep	2	1,755 0 0	16 327	
42	Machines, drilling double geared to drill holes 2" × 7" .	2	5,313 0 0	16 563	
	Carried over .		202,788 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount			Approximate rates of exchange at which purchases of machines have been calculated	REMARKS
			Rs	A	P	Pence per rupee	
	Brought forward		202 788	0	0		
	Machine and Fitting Shops— *(contd.)*						
43	Machine drilling double geared to drill holes 2¼" × 9	1	4 050	0	0	16 327	
44	Machine drilling and boring double geared to drill holes 3 × 12"	1	4 600	0	0	16 327	
45	Machine drilling radial medium size	1	3 199	0	0		Purchased in India
46	Machine drilling and tapping radial to drill holes 2" × 15"	1	3 770	0	0	15 425	
47	Machine horizontal slot drilling single head medium size	1	4 294	0	0		Ditto
48	Machine traversing drilling to cut slots about 8" long 1 ft broad and 6 deep	1	2 262	0	0	15 425	
49	Machine milling universal double geared	1	5 287	0	0	16 327	
50	Dividing head with centres for use with above	1	371	0	0	15 425	
51	Machine milling and slotting combined 10" stroke	1	6 032	0	0	15 425	
52	Machine milling and profiling to mill 30" × 7 × 5"	1	4 721	0	0	15 425	
53	Machine horizontal milling to mill 15 in length and to admit 2 in width by 1 6" in height	1	5,382	0	0	15 425	
54	Machine cutter forming with dividing apparatus	1	858	0	0	15 425	
55	Machine cutter grinding complete	1	1 612	0	0	15 425	
56	Machine brass finishing single speed head stock and cone pulley on hollow spindle	1	1 687	0	0	16 563	
57	Machine cock grinding reciprocating for cocks up to 2 bore	1	1 045	0	0	16 327	
58	Machine centring and bolt pointing	1	754	0	0	15 425	
59	Machine emery grinding universal with wheels 20 diameter	1	1 947	0	0	15 563	
60	Machine emery grinding with wheels 36 diameter	1					
61	Machine emery grinding 20" diameter	1	300	0	0		Purchased in India
62	Machine shaping single headed 6 stroke	1	110	0	0		Ditto
63	Machines shaping single headed with single table 9 stroke	2	3 507	0	0	16 956	
64	Machine shaping single headed with single table 10 stroke	1	2 355	0	0	15 425	
65	Machines double shaping 12 stroke	2	6 434	0	0		Purchased in India
	Carried over		265 065	0	0		

Southern Mahratta Railway Workshops — Subject 15

Item No.	DESCRIPTION	No.	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
			Rs A P	Pence per rupee	
	Brought forward		2,65,065 0 0		
	Machine and Fitting Shops— (*contd.*)				
66	Machine planing 4' × 2' × 1' 6" with single head	1	3,054 0 0	16·563	
67	Machine planing 5' × 2' 6" × 2' with single head	1	3,677 0 0	15·425	
68	Machine planing 6' × 3' × 2' 6", with double head	1	4,044 0 0		Purchased in India
69	Machine planing 8' × 4' 6" × 4' with double head and apparatus fixed to side of bed for planing on edge of table	1	6,040 0 0	16·563	
70	Machine quartering horizontal for turning locomotive engine crank pins up to 12" long × 4" diameter	1	9,003 0 0	16·327	
71	Machines screwing and tapping ¼" to 1"	2	2,683 0 0		Purchased in India
72	Machine screwing and tapping ¼" to 1½", with set of 9 master taps of sizes	1	1,654 0 0	16·327	
73	Machine screwing and tapping, ½" to 2"	1	1 01 0 0		Purchased in India
74	Machine screwing and tapping up to 3" diameter	1	1,820 0 0		Ditto
75	Machines slotting 6" stroke	2	4,128 0 0	15·425	
76	Machine slotting 8" stroke	1	1,846 0 0		Ditto.
77	Machine slotting 12" stroke	1	2,690 0 0		Ditto
78	Machine band sawing for cold metal	1	3,306 0 0	15·425	
79	Machine testing for steam pressure gauges	1	109 0 0	16·936	
80	Machine oil testing	1	350 0 0	16·3 7	
81	Machine weighing platform 2' 6" × 2' 6" to weigh up to 5 cwts	1	138 0 0	16·327	
82	Machine weighing circular to weigh up to 8 lbs	1	4 0 0	17·878	
83	Plate marking off with stand	1	1,068 0 0		Made in shops
84	Press hydraulic wheel to press up to 200 tons	1	6,778 0 0		Purchased in India
85	Tapper Pearn's Patent lightning with 2 sets of taps	1	858 0 0	15·425	
86	Traverser wheel	1	500 0 0	15·425	
87	Trolly	1	160 0 0		Made in shops
88	Brackets of sorts, bolts and nuts, drums, girder, leather belting, shafting and pulleys		21,222 0 0		
89	Cost of erection of the above machines		41,990 0 0		
90	Cost of miscellaneous tools supplied to Machine and Fitting Shops		18,809 0 0		
	TOTAL		4,02,497 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No.	Amount.			Approximate rates of exchange at which prices of the machines have been calculated	REMARKS.
			Rs	A	P	Pence per rupee	
	2—Grinding Shop						
1	Dresser, grindstone complete	1	2 971	0	0	16 363	
2	Grindstones 7 × 12'	2					
3	Machine band polishing	1	815	0	0	16 363	
4	Machine emery buffing	1	511	0	0		Purchased in India
5	Machine emery grinding for slide bars	1	2 356	0	0	16 327	
6	Machine grinding vertical with rising and falling spindle	1	1 415	0	0	15 425	
7	Shafting girders wall brackets, etc		960	0	0		
8	Cost of erection of the above machines		1 109	0	0		
9	Cost of miscellaneous tools supplied to Grinding Shop		707	0	0		
	TOTAL		10 844	0	0		

Southern Mahratta Railway Workshops — Subject 15

Item No.	DESCRIPTION	No	Amount			Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
			Rs	a	p	Pence per rupee	
	3—Erecting Shop						
1	Barrows hand	2	46	0	0		Made in shops.
2	Cranes overhead travelling 25 tons hydraulic	2	32 322	0	0	16 205	
3	Indicators steam engine Darke's complete with springs and scales	2	568	0	0	15 425	
4	Machine cylinder boring portable	1	1 150	0	0	16 563	
5	Machine engine weighing Ehrhardt's (1 set of 8)	1	1 544	0	0	16 563	For use at out stations
6	Machine engine weighing Ehrhardt's (1 set of 10)	1	3 500	0	0	15 425	
7	Machine steam chest face planing portable	1	360	0	0	17 247	
8	Machine slide valve setting Sonenthal's patent	1	177	0	0	16 205	
9	Machine portable for facing horn plates ..	1	930	0	0	17 247	
10	Machine weighing platform 2 6" × 2 6", to weigh up to 5 cwts.	1	139	0	0	16 205	
11	Machine, weighing Salter's patent	1	12	0	0		
12	Pump boiler testing hydraulic	1	150	0	0		Purchased in India.
13	Shunting apparatus Sonenthal's	1	324	0	0	16 205	
14	Traverser pit hand power	1	4 369	0	0	16 327	
15	Cost of erection of the above machines		3 558	0	0		
16	Cost of miscellaneous tools supplied to Erecting Shop		16 764	0	0		
	TOTAL		65 913	0	0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS.
	4—Boiler Shop		Rs. A P	Pence per rupee	
1	Blower, Root's patent, No. 1	1	599 0 0	16 327	
2	Crane, overhead travelling, 12 tons, hand power	1	4 338 0 0	16 327	
3	Cranes, wall, with 18′ horizontal jib	2	3 770 0 0	15 425	
4	Engine, portable, 12 H P	1	2 620 0 0		Purchased in India
5	Forges, portable, 20″ diameter	13	1 [illegible]40 0 0		Ditto
6	Forges, portable, with Root's blowers	8	1,385 0 0		Ditto
7	Forges, blacksmiths', single fire, complete	6	2 400 0 0		Ditto
8	Forges, blacksmiths', with Root's blowers and hearth plates complete	3	1 868 0 0	15 425	
9	Grindstone, 6′ × 8″, with trough	1	1 033 0 0	16 205	
10	Machines, drilling, single geared, to drill holes ¾″ × 6″ deep	2	1 755 0 0	16 327	
11	Machine, drilling, single geared, to drill holes 1″ × 6″	1	1 32[illegible] 0 0	15 425	
12	Machines, drilling, flexible, Stow's patent, to drill holes up to 1¼″ diameter	2	905 0 0	16 327	
13	Machines, drilling, radial	2	8 815 0 0	14 757	
14	Machine, drilling, multiple	1	5 000 0 0	15 425	
15	Machine, angle iron bending	1	4 [illegible]16 0 0	15 425	
16	Machine, plate bending, to take plates up to 6′ 1″ × [illegible]	1	1 380 0 0	16 936	
17	Machine, plate bending, to take plates up to 8′ 1″ × [illegible]″	1	2 003 0 0	16 936	
18	Machine, plate edge planing	1	6 217 0 0	15 425	
19	Machine, lever punching and shearing, [illegible] holes in ¼ plate	1	350 0 0	16 936	
20	Machine, punching and shearing, to punch ½ hole in ⅜ plates and shear ⅜ plates	1	839 0 0	16 936	
21	Machine, punching and shearing, to punch holes 1″ × 1″ and shear 1 bars	1	3 280 0 0	17 931	
22	Machine, punching and shearing, to punch [illegible]″ holes in ¾″ plates	1	3 182 0 0		Purchased in India
23	Machine, punching and shearing, hand, to punch [illegible] holes in ½ plates and shear ½ plates	1	605 0 0	15 425	
24	Machines, portable, for cutting out boiler tubes in position	2	161 0 0	16 936 & 16 3[illegible]	
25	Machine for cleaning boiler tubes externally	1	1 828 0 0	16 327	
	Carried over		61 157 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No.	DESCRIPTION	No	Amount Rs	a	p	Approximate rates of exchange at which prices of the machines have been calculated	Remarks
			Rs	a	p	Pence per rupee	
	Brought forward		61 157	0	0		
	Boiler Shop—(contd.)						
26	Machine tube cutting	1	342	0	0		From B K R
27	Machine tube sawing	1	661	0	0	15 425	
28	Machine weighing platform 2' 6" × 2' 6" to weigh up to 5 cwts	1	142	0	0	16 205	
29	Pump boiler testing hydraulic	1	984	0	0		Purchased in India
30	Pump boiler testing hydraulic barrow	1	371	0	0	15 425	For use at out stations
31	Trolly boiler	1	314	0	0		Made in shops.
32	Tube beaders	2	177	0	0	16 205	
33	Tube cambering press	1	150	0	0	15 425	
34	Brackets of sorts shafting drums pipes bolts and nuts and wall boxes		6 382	0	0		
35	Cost of erection of the above machines		7 933	0	0		
36	Cost of miscellaneous tools supplied to Boiler Shop		15 283	0	0		
	TOTAL		93 896	0	0		
	5—Smithy						
1	Blowers Root's patent No 3	3	3 681	0	0		1 spare
2	Boiler locomotive supplying steam to steam hammers	1	8 491	0	0	15 425	
3	Centres and head stocks for straightening bent axles	1	1 019	0	0	16 327	
4	Cranes column 15 ft radius 10 cwts	2	1 500	0	0		Made in shops
5	Crane column 17 ft radius 10 cwts	1	600	0	0		Ditto
6	Crane independent 3 tons 12 ft radius	2	3 719	0	0	16 205	
7	Engine portable 12 H P	1	4 000	0	0		Purchased in India
8	Forges portable with Root's blowers	5	865	0	0		Ditto
9	Forges blacksmiths single	31	17 906	0	0		Made in shops
10	Forges six fire C I complete	3	2 50	0	0		Ditto
11	Furnace case hardening with boxes	1	200	0	0		Ditto
12	Furnace fire tempering	1	150	0	0		Ditto
13	Furnaces spring	2	2 65	0	0	16 563	
14	Furnace tyre	1	1 433	0	0	16 327	
15	Grindstone 6 × 8" with trough	1	762	0	0		Purchased in India
	Carried over		49 233	0	0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount Rs.	a	p	Approximate rates of exchange at which prices of the machines have been calculated.	REMARKS.
	4—Boiler Shop		Rs.	a	p	Pence per rupee	
1	Blower Root's patent, No. 1	1	599	0	0	16 327	
2	Crane overhead travelling 12 tons hand power	1	4 338	0	0	16 327	
3	Cranes wall with 18 horizontal jib	2	3 770	0	0	15 425	
4	Engine portable 12 H P	1	2 620	0	0		Purchased in India.
5	Forges portable 20" diameter	13	1 240	0	0		Ditto.
6	Forges portable with Root's blowers	8	1 385	0	0		Ditto
7	Forges blacksmiths, single fire complete	6	2 400	0	0		Ditto
8	Forges blacksmiths with Root's blowers and hearth plates complete	3	1 868	0	0	15 425	
9	Grindstone, 6 × 8" with trough	1	1 033	0	0	16 205	
10	Machines drilling single geared to drill holes ¾ × 6 deep	2	1 755	0	0	16 327	
11	Machine drilling single geared to drill holes 1" × 6	1	1 322	0	0	15 425	
12	Machines drilling flexible Stow's patent to drill holes up to 1¼ diameter	2	903	0	0	16 327	
13	Machines drilling radial	2	8 815	0	0	14 757	
14	Machine drilling multiple	1	5 000	0	0	15 425	
15	Machine, angle iron bending	1	4 216	0	0	15 425	
16	Machine plate bending to take plates up to 6 1" × 7/16"	1	1 380	0	0	16 936	
17	Machine plate bending to take plates up to 8 1" × ⅜"	1	2 003	0	0	16 936	
18	Machine plate edge planing	1	6 217	0	0	15 425	
19	Machine lever punching and shearing ½ holes in ½ plate	1	350	0	0	16 936	
20	Machine punching and shearing to punch ¾ holes in ¾ plates and shear ¾ plates	1	889	0	0	16 936	
21	Machine punching and shearing to punch holes 1" × 1" and shear 1 bars	1	3 080	0	0	17 931	
22	Machine punching and shearing to punch ¾ holes in ¾" plates	1	3 182	0	0		Purchased in India.
23	Machine punching and shearing hand to punch 9/16 holes in ½ plates and shear ½ plates	1	605	0	0	15 425	
24	Machines portable for cutting out boiler tubes in position	2	161	0	0	16 936 & 16 327	
25	Machine for cleaning boiler tubes externally	1	1 828	0	0	16 327	
	Carried over		61 157	0	0		

Southern Mahratta Railway Workshops — Subject 15

Item No.	DESCRIPTION	No	Amount	Approximate rates of exchange at which prices of the machines have been calculated	Remarks
			Rs. a. p.	Pence per rupee	
	Brought forward		*61 157 0 0*		
	Boiler Shop—(contd.)				
26	Machine tube cutting	1	342 0 0		From B K R
27	Machine tube sawing	1	661 0 0	15 425	
28	Machine weighing platform 2 6" × 2' 6" to weigh up to 5 cwts	1	142 0 0	16 205	
29	Pump boiler testing hydraulic	1	984 0 0		Purchased in India
30	Pump boiler testing hydraulic barrow	1	371 0 0	15 425	For use at out stations
31	Trolley boiler	1	314 0 0		Made in shops.
32	Tube beaders	2	177 0 0	16 205	
33	Tube cambering press	1	150 0 0	15 425	
34	Brackets of sorts shafting drums pipes bolts and nuts and wall boxes		6 382 0 0		
35	Cost of erection of the above machines		7 933 0 0		
36	Cost of miscellaneous tools supplied to Boiler Shop		15 283 0 0		
	TOTAL ...		93,896 0 0		
	5—Smithy				
1	Blowers Root's patent No 3	3	3 681 0 0		1 spare
2	Boiler locomotive supplying steam to steam hammers	1	8,491 0 0	15 425	
3	Centres and head stocks for straightening bent axles	1	1 019 0 0	16 327	
4	Cranes column 15 ft radius 10 cwts	2	1 500 0 0		Made in shops
5	Crane column 17 ft radius 10 cwts	1	600 0 0		Ditto
6	Crane independent 3 tons 12 ft radius	2	3 719 0 0	16 205	
7	Engine portable 12 H P	1	4 000 0 0		Purchased in India
8	*Forges portable with Root's blowers*	5	*865 0 0*		*Ditto*
9	Forges blacksmiths single	31	17 906 0 0		Made in shops
10	Forges six fire C I complete	3	2 250 0 0		Ditto
11	Furnace casehardening with boxes	1	200 0 0		Ditto
12	Furnace fire tempering	1	150 0 0		Ditto
13	Furnaces spring	2	265 0 0	16 563	
14	Furnace tyre	1	1 433 0 0	16 327	
15	Grindstone 6 × 8" with trough	1	762 0 0		Purchased in India
	Carried over		49 233 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
			Rs A P	Pence per rupee.	
	Brought forward ...		49 233 0 0		
	Smithy—(*contd*)				
16	Machine, bolt, nut and rivet making, with furnace complete	1	9 645 0 0	16 327	
17	Machine, forging, with 6 pairs of hammers	1	3,770 0 0	15 425	
18	Machine, hot iron sawing with saws 30" diameter	1	1,250 0 0	17 247	
19	Machine, punching and shearing, to punch 1" holes through ¾" plates ..	1	713 0 0	...	From B. K. R.
20	Machine, spring testing, horizontal, to test up to 7½ tons	1	3,360 0 0	16 563	
21	Machine weighing platform, 2 6"× 2 6" to weigh up to 5 cwts	1	141 0 0	17 247	
22	Steam hammers double acting Rigby's patent 3 cwts	2	2,826 0 0	16 563	
23	Steam hammer double acting Rigby's patent, 5 cwts	1	2,355 0 0	16 563	
24	Steam hammer double acting Rigby's patent, 15 cwts	1	3 500 0 0	16 327	
25	Steam hammer, double acting, Rigby's patent, 30 cwt	1	5 770 0 0	16 205	
26	Steam stamp special, Massey's 5 cwts	1	2,270 0 0	16 327	
27	Trollies	2	320 0 0		Made in shops
28	Water bosh, 6 ft diameter, W. I, complete	1	375 0 0		Ditto
29	Brackets drums, pipes of sorts and plates		5 214 0 0		
30	Cost of erection of the above machines		10,023 0 0		
31	Cost of miscellaneous tools supplied to Smithy		17,529 0 0		
	TOTAL		1,18 294 0 0		

Southern Mahratta Railway Workshops — Subject 15.

Item No.	DESCRIPTION.	No.	Amount.	Approximate rates of exchange at which prices of the machines have been calculated.	Remarks.
	6—Foundry and Pattern Shop		Rs A. P	Pence per rupee	
1	Blower, Root's patent	1	923 0 0	...	Purchased in India
2	Core oven, 9 ft. × 6 ft., inside	1	695 0 0	. .	} *Made in shops*
3	Core oven, 20 ft × 10 ft., inside	1	1,490 0 0	...	
4	Cranes, column, 20 ft radius, 1½ tons	3	2,733 0 0	16·327	
5	Crane, independent, 5 tons, 20 ft radius	1	3,485 0 0	16·327	
6	Cupola, to melt 1½ tons per hour ...	1	2,565 0 0	.	Purchased in India
7	Cupola, Stewart's patent to melt 2 tons per hour, with spare parts ..	1	1,800 0 0	16·327	
8	Cupola, Stewart's patent, to melt 3 tons per hour, with spare parts	1	2 195 0 0	16·327	
9	Staging for the above	1	644 0 0	...	*Made in shops*
10	Furnaces, hot air, annular, Fletcher's patent, capacity 100 lbs	3	2,665 0 0	17·247	
11	General joiner, complete, with rising and falling table for pattern maker's use	1	5 185 0 0	15·425	
12	Grindstone, 3' 6" × 6", with trough, complete	1	132 0 0	16·205	
13	Lift, hydraulic, with pumps and accumulator for cupola staging ..	1	2,100 0 0	15·425	
14	Machine, emery grinding, for dressing light castings	1	940 0 0	15·425	
15	Machine, magneting ...	1	268 0 0	16·327	
16	Machine, moulding, for axle-box brasses etc	1	550 0 0	16·563	
17	Machine, moulding, for axle-boxes, etc	1	1,081 0 0	16·563	
18	Machine, weighing platform, 2' 6"×2' 6", to weigh up to 5 cwts	1	105 0 0	17·931	
19	Mill, mortar, with revolving pan	1	3 665 0 0	16·563	
20	Trollies ...	2	328 0 0		Made in shops
21	Pipes of sorts, drums, etc ..		485 0 0	. .	
22	Cost of erection of the above machines		3 727 0 0		
23	Cost of miscellaneous tools supplied to Foundry and Pattern Shop		6 407 0 0		
	TOTAL .	. .	44,168 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount	Approximate rates of exchange at which the prices of the machines have been taken	Remarks
	7 —Coppersmithy and Tinsmithy		Rs A P	Pence per rupee	
1	Hearth coppersmiths 18" high	1	196 0 0		Made in shops.
2	Hearths coppersmiths 26" high	3	424 0 0		
3	Machine circle edge bending	1	26 0 0		
4	Machine circle cutting	1	48 0 0		
5	Machine folding	1	52 0 0	16·936	
6	Machine guillotine shears	1	69 0 0		
7	Machine punching	1	50 0 0		
8	Machine planishing (Longworth's) 30 lbs		1,320 0 0	17·931	
9	Machine hand-drilling	1	238 0 0		From B. K. R
10	Machine stamping heavy	1	565 0 0	17·261	
11	Machine tube sawing and rose bitting	1	961 0 0	16·936	
12	Machine tube testing	1	689 0 0	16·563	
13	Machine tube drawing with dies complete	1	1,127 0 0	16·327	
14	Rolls plate bending 36"	1	64 0 0	16·936	
15	Cast iron pipes of sorts		183 0 0		
16	Cost of erection of the above machines		540 0 0		
17	Cost of miscellaneous tools supplied to Coppersmithy and Tinsmithy		4,136 0 0		
	TOTAL		10,688 0 0		
	8 —Trimming Shop				
1	Machine sawing	1	110 0 0		Purchased in India
	TOTAL		110 0 0		
	9 —Carriage Shop				
1	Forges portable 20" diameter	6	467 0 0	16·327	
2	Lathe wheel duplex carriage and wagon for turning wheels from 21" to 30" diameter	1	6,520 0 0	15·68	
3	Machine drilling hand	1	238 0 0		From B. K. R
4	Machine screwing Sellars's patent	1	1,600 0 0	15·425	
5	Cost of erection of the above machines		2,495 0 0		
6	Cost of miscellaneous tools supplied to Carriage Shop		16,080 0 0		
	TOTAL		27,400 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount Rs A P	Approximate rate of exchange at which prices of the machines have been calculated	REMARKS.
	10—Saw Mill.		Rs A P	Pence per rupee	
1	Boilers (Fairbairn and Beely's patent) for 35 H P engine ..	2	18,114 0 0	16 563	
2	Crane, over head travelling, hand, 3 tons	1	2 455 0 0	16 327	
3	Crane, travelling, hand, 3 tons	1	3 826 0 0	16 327	
4	Engine, stationary, 35 H P, horizontal, compound condensing	1	11,387 0 0	16 936	
5	General-joiner ...	1	3 309 0 0	.	Purchased in India
6	Grindstone, 6' × 8", with trough	1	1,033 0 0	16 478	
7	Grindstone, 6' × 8", with C I trough and revolving set stone, including spare stones	1	1,597 0 0	16 327	
8	Lathe, wood cutting, 10" centre	1	535 0 0	..	Purchased in India.
9	Machine, emery grinding, for moulding cutters	1	1,152 0 0	16 327	
10	Machine, double spindle, irregular moulding and shaping .	1	798 0 0	16 205	
11	Machine, band sawing wheel 36" diameter, with spare saws	1	840 0 0	16 205	
12	Machines, mortising hand, 2' × 9"	2	625 0 0		Purchased in India.
13	Machine, saw sharpening	1	406 0 0		
14	Machine, saw gulleting	1	316 0 0		
15	Machine, *surface planing* Richard s patent, to take 24" × 7"	1	1,884 0 0	16 327	
16	Machine, vertical boring single spindle, for boring up to 2" × 12"	1	1,419 0 0	16 205	
17	Machine, vertical, mortising and boring	1	1 964 0 0	16 205	
18	Machine, weighing platform 2 6" × 2' 6", to weigh up to 5 cwts	1	70 0 0	16 936	
19	Saw benches, circular 36"	3	1 599 0 0		Purchased in India.
20	Saw bench, circular, combined ripping and cross cutting to carry two saws, up to 20" diameter	1	1,333 0 0	17 931	
21	Saw bench, circular, rising and falling spindle, to 24" diameter	1	1 027 0 0	16 205	
22	Saw bench cross cut to carry saws up to 42" diameter, with spare saws	1	2 728 0 0	16 205	
23	*Saw bench circular, to carry saws to* 48" diameter, with spare saws	1	1,612 0 0	17 931	
24	Saw bench, circular, 7' 6" × 3 6", with countershaft	1	1,720 0 0	15 425	
	Carried over .		61,549 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS.
			Rs A. P	Pence per rupee	
	Brought forward		61,549 0 0		
	Saw Mill—(contd)				
25	Saw bench, rack, complete, for 30' logs ...	1	7,076 0 0	15 425	
26	Saw, reciprocating, cross cut, to cut logs, up to 30" diameter	1	1 143 0 0	16 205	
27	Saws, circular, additional, for saw benches	6	1,693 0 0	15 425	
28	Saw, log frame	1	5 950 0 0		Purchased in India.
29	Trollies	4	427 0 0		Made in shops.
30	Brackets of sorts, bolts and nuts, drums shafting, etc		5 830 0 0		
31	Cost of erection of the above machines		10 600 0 0		
32	Cost of miscellaneous tools supplied to Saw Mill		1 693 0 0		
	TOTAL		94 021 0 0		
	II —Paint Shop.				
1	Mills, paint grinding	4	285 0 0	16 327	
2	Traverser, carriage, 13 ft 6 in long	1	1,125 0 0	16 327	
3	Cost of erection of the above machines ...		140 0 0		
4	Cost of miscellaneous tools supplied to Paint Shop		1,099 0 0		
	TOTAL		2 649 0 0	..	

S. M. R Workshops—Subject 15.

Item No	DESCRIPTION	No.	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
	12.—Engine Room		Rs A P	Pence per rupee	
1	Boilers (Fairbairn's and Beely's patent) for 50 H P stationary engine . . .	2	21,997 0 0	16 936	
2	Engine, stationary, 50 H P horizontal compound condensing, complete	1	21 775 0 0	16 936	
3	Cost of erection of the above .		6,266 0 0		
	TOTAL .		50 038 0 0		
	13.—Workshop Yard				
1	Fire engines hand	2	3 731 0 0	16 205	
2	Troughs and hose pipes for fire-engines	2	219 0 0		Purchased in India
3	Shear legs, with crab winch and tackle complete . .	1	553 0 0		Do. do
4	Traversers carriage 13 ft 6 in long .	3	3,496 0 0	16·478	
5	Cost of erection of the above machines		561 0 0	..	
6	Cost of miscellaneous tools supplied for use in Workshop Yard		1 378 0 0	—	
	TOTAL		9 938 0 0		

Southern Mahratta Railway Workshops — Subject 15

Item No	DESCRIPTION	No	Amount.	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
			Rs A P	Pence per rupee	
	Brought forward		61 549 0 0		
	Saw Mill—(contd)				
25	Saw bench, rack, complete for 30 logs	1	7 076 0 0	15 425	
26	Saw, reciprocating cross cut to cut logs, up to 30" diameter	1	1 143 0 0	16 .05	
27	Saws, circular, additional, for saw benches	6	1,693 0 0	15 425	
28	Saw, log frame	1	3 950 0 0		Purchased in India.
29	Trollies	4	427 0 0		Made in shops.
30	Brackets of sorts, bolts and nuts, drums shafting etc		5 830 0 0		
31	Cost of erection of the above machines		10 600 0 0		
32	Cost of miscellaneous tools supplied to Saw Mill		1 633 0 0		
	TOTAL		94 021 0 0		
	II —Paint Shop.				
1	Mills, paint grinding	4	285 0 0	16 327	
2	Traverser, carriage, 13 ft 6 in long	1	1 125 0 0	16 327	
3	Cost of erection of the above machines		140 0 0		
4	Cost of miscellaneous tools supplied to Paint Shop		1 099 0 0		
	TOTAL		2 649 0 0		

S. M. R. Workshops—Subject 15.

Item No	DESCRIPTION	No.	Amount	Approximate rates of exchange at which prices of the machines have been calculated	REMARKS
	12.—Engine Room.		Rs A P	Pence per rupee	
1	Boilers (Fairbairn's and Beely's patent) for 50 H P stationary engine	2	21,997 0 0	16·936	
2	Engine, stationary, 50 H P horizontal compound condensing, complete	1	21 775 0 0	16 936	
3	Cost of erection of the above . .		6,266 0 0		
	TOTAL .		50 038 0 0		
	13.—Workshop Yard.				
1	Fire engines hand	2	3 731 0 0	16 205	
2	Troughs and hose pipes for fire-engines	2	219 0 0		Purchased in India
3	Shear legs, with crab winch and tackle, complete . .	1	553 0 0		Do. do
4	Traversers, carriage 13 ft 6 in long .	3	3,496 0 0	16 478	
5	Cost of erection of the above machines		561 0 0	...	
6	Cost of miscellaneous tools supplied for use in Workshop Yard		1 378 0 0	...	
	TOTAL		9 938 0 0		

S M R Workshops—Subject 15.

Tools and Plant—Hubli Workshops

ABSTRACT

No	NAME OF SHOP	COST OF				TOTAL
		Machinery	Shafting pulleys girders &c	Erection	Miscellaneous tools	
		Rs	Rs	Rs	Rs	Rs.
1	Machine and Fitting Shops	3,20,476	21 222	41,990	18 809	4,02 497
2	Grinding Shop	8,068	960	1 109	707	10 844
3	Erecting Shop	45 591		3 558	16 764	65 913
4	Boiler Shop	64 298	6 382	7 933	15 283	93 896
5	Smithy	85 528	5 214	10 023	17 529	1 18 294
6	Foundry and Pattern Shop	33 549	485	3 727	6,407	44 168
7	Coppersmithy and Tinsmithy	5 829	183	540	4 136	10,688
8	Trimming Shop	110				110
9	Carriage Shop	8 825		2 495	16 080	27 400
10	Saw Mill	75 838	5 890	10 600	1 693	94 021
11	Paint Shop	1 410		140	1 099	2 649
12	Engine Room	43 772		6 266		50 038
13	Workshop Yard	7 999		561	1 378	9 938
14	TOTAL	7 01 293	40 336	88 942	99,885	9 30 456
15	Estimated further expenditure for complete equipment	55,407	3 164	7 258	3 415	69 244
16	Grand total for complete equipment	7 56 700	43 800	96 200	1 03 300	10 00 000

HUBLI
6th October 1894

C P WHITCOMBE
Locomotive and Carriage Superintendent

SOUTH INDIAN RAILWAY WORKSHOPS AT NEGAPATAM — SUBJECT 15

Note by Mr C E Crighton, Locomotive and Carriage Superintendent, South Indian Railway dated Negapatam, 7th November 1894

General description

The construction of the South Indian Railway workshops was commenced about 1862, at which time the line was the standard 5 ft 6 in gauge from Negapatam to Trichinopoly, a distance of 79 miles, the line was afterwards extended to Erode, making the total length of 5 ft 6 in gauge 166½ miles, and the workshops as originally designed were intended to serve about 200 miles of standard gauge Railway Since 1875 the Railway has been converted into metre gauge, and at the present time the total length of line worked by the South Indian Railway Company is 1,049 miles The workshops have been considerably enlarged and the relative positions of the several shops and of the general stores buildings are illustrated in plate LII

A brief description of these shops is given in Volume V, page 129

The total area of the ground occupied by the workshops and yard is nearly 17 acres.

Mileage Statistics, 1893

Of the total length of line worked by the Company, *viz*, 1 049 miles the engine and train mileage run during the twelve months ending 31st December 1893 was 37,44 853

Rolling Stock

The following particulars give the amount of rolling stock —

Locomotives	204
Coaching vehicles	928
Goods do	3,380

Machinery and Tools

The following list of machinery gives the particulars and distribution to the several shops together with cost of each machine —

S I R Workshops—Subject 15

Tools and Plant—Negapatam Workshops

Item No	DESCRIPTION	No	Approximate value	Remarks
			R a p	
	Carriage Shop, including Saw Mill			
1	Engine stationary horizontal 30 H P with two boilers	1	18 335 0 0	
2	Machine vertical saw	1	1 101 0 0	
3	band saw	1	698 0 0	
4	circular saw	4	2 132 0 0	
5	saw sharpening	2	612 0 0	
6	drilling	1	261 0 0	
7	mortising hand	1	100 0 0	
8	general purpose and mortising	1	2 705 0 0	
9	double tenoning and cutting	1	1 640 0 0	
10	tenoning	1	640 0 0	
11	hand feed surface planing and jointing	1	607 0 0	
12	planing and thicknessing	1	1,869 0 0	
13	planing	2	4 046 0 0	
14	moulding and planing	1	2 658 0 0	
15	irregular and circular moulding	1	718 0 0	
16	automatic cutter grinding	1	902 0 0	
17	plain saw bench	1	566 0 0	
18	boring wood	1	344 0 0	
19	iron	2	400 0 0	
20	sawing	1	140 0 0	
21	weighing	4	972 0 0	
22	*Lathe wood turning large*	1	600 0 0	
23	small	1		
24	made in shops	1	150 0 0	
25	Crane 3 ton	1	2 763 0 0	
26	Engine fire hand	1	1 160 0 0	
27	Forges portable	3	300 0 0	
28	Grindstones with iron trough	3	120 0 0	
29	Trimmer Fox universal	4	630 0 0	
30	Traverser carriage and wagon	1	2 410 0 0	
31	small	1	842 0 0	
32	Pump steam	1	1 200 0 0	
33	Shafting pulleys and plummer blocks for driving machines		2 752 0 0	
34	Cost of erection of the above machines		5 437 0 0	
35	Cost of miscellaneous tools supplied to Carriage Shop		29,500 0 0	
	TOTAL Rs		89 3 0 0 0	

S. I R. Workshops—Subject 15.

Item No	DESCRIPTION	No	Approximate value	Remarks
			R a. p	
	Tool Shop.			
1	Engine, stationary, 30-H P, horizontal	1	6011 0 0	
2	Boiler, stationary, Galloway, single, tubular	4	16030 0 0	
3	Machine, planing 12' table	1	} 4614 0 0	
4	" " 5' 6" do.	2		
5	" grinding and planing, slide bar	1	2700 0 0	
6	" slotting, large	1	1593 0 0	
7	" " small, for light works	1	797 0 0	
8	" single-geared drilling	2	1357 0 0	
9	" double " "	2	2100 0 0	
10	" drilling radial, large	1	1440 0 0	
11	" " " medium	2	1878 0 0	
12	" drilling	2	1357 0 0	
13	" " small, made in shops	3	150 0 0	
14	" cotter hole cutting and drilling	1	908 0 0	
15	" wheel drilling	2	2075 0 0	
16	" treadle drilling	1	780 0 0	
17	" screwing double geared, ½" to 1½"	1	1,168 0 0	
18	" " " " ½" to 2"	2	2236 0 0	
19	" " single geared, ½" to 1½"	1	1,045 0 0	
20	" single, ½" to 2"	2	2190 0 0	
21	" Barrow's patent screwing and turning	1	4096 0 0	
22	" shaping, medium, 10" stroke	2	3487 0 0	
23	" large, 14" stroke	1	1975 0 0	
24	" " small, 4½" stroke	1	854 0 0	
25	" " double head, 9"	1	1556 0 0	
26	" " 20" stroke	1	1975 0 0	
27	" patent polishing double, 3' diameter	1	2500 0 0	
28	" testing steam gauge	1	510 0 0	
29	" boring axle brass	2	2104 0 0	
30	" brass finishing	1	900 0 0	
31	" wheel cutting tooth	1	1,296 0 0	
32	" patent universal cutter B size grinding with gear complete	1	872 0 0	
33	" cutter grooving	1	2113 0 0	
34	" buffing	1	1166 0 0	
35	" quartering	1	10169 0 0	
36	" shafting	2	1509 0 0	
37	" " nut	1	910 0 0	
38	" weighing	2	486 0 0	
	Carried over		89,307 0 0	

S I R Workshops—Subject 15

Item No	Description	No	Approximate value R	a	p	Remarks
	Tool Shop—*continued*					
	Brought forward Rs		89 307	0	0	
39	Lathe wheel narrow gauge	4	14 237	0	0	
40	1 6½" centre	4	2 232	0	0	
41	broad gauge 3 8"	2	12 756	0	0	
42	2 3"	1	4,4[illegible]8	0	0	
43	single geared brass finishing 7" centre	1	644	0	0	
44	brass finishing 5" centre	1	742	0	0	
45	turning self acting 12½" centre	1	1,465	0	0	
46	double geared 9½" centre	2	1 550	0	0	
47	axle	1	1 777	0	0	
48	double end turning complete	1	532	0	0	
49	geared with shifting bed plate 11" centre	1	2 420	0	0	
50	gap self-acting 9½ centre	1	1 500	0	0	
51	sliding surfacing and screw cutting 12" centre	1				
52	" 10"	1	3 338	0	0	
53	7"	2				
54	gap and screw cutting 6"	1	700	0	0	
55	10"	1	1 900	0	0	
56	double geared self acting sliding surfacing 16 centre	1	2 285	0	0	
57	self acting sliding and surfacing 18 centre	2	12 735	0	0	
58	screw cutting 10½" centre	1	1 450	0	0	
59	6"	1	700	0	0	
60	9½"	1	1 500	0	0	
61	7"	2	1 652	0	0	
62	boring type	2	4,250	0	0	
63	lapping	2	200	0	0	
64	nut facing	1	530	0	0	
65	Crane jib with traversing action	1	1 000	0	0	
66	3 ton travelling	1	2 763	0	0	
67	Emery tool grinder patent 1 8" diameter	1	647	0	0	
68	" 3	2	2 482	0	0	
69	Template Whitworth and standard T plate boring boxes	2	800	0	0	
70	Traverser overhead 10 ton	1	4 860	0	0	
71	Stand pipe and pump complete	1	500	0	0	
72	Shafting and pulleys with plummer blocks complete		11 865	0	0	
73	Cost of erection of the above machines		18 923	0	0	
74	Cost of miscellaneous tools supplied to Tool Shop		16 000	0	0	
	TOTAL Rs		2 24 160	0	0	

S I R Workshops—Subject 15.

Item No	DESCRIPTION	No	Approximate value			REMARKS
	Boiler Shop		*R*	*a*	*p*	
1	Engine stationary with boiler	1	13 066	0	0	
2	Machine punching washers and cutting round iron	1	104	0	0	
3	,, punching and shearing	1	1 592	0	0	
4	,, shearing hand	1	889	0	0	
5	drilling	2	1 680	0	0	
6	wall drilling	1	603	0	0	
7	cutting tube	1	342	0	0	
8	,, cleaning tube	1	200	0	0	
9	,, bending plate	1	1,871	0	0	
10	sawing hot iron	1	797	0	0	
11	,, tube swaging made in shop	1	20	0	0	
12	weighing	1	243	0	0	
13	Crane for smith fires	2	340	0	0	
14	Forges portable	15	1 500	0	0	
15	Grindstone with trough	1	40	0	0	
16	Pump test complete	1	272	0	0	
17	Punches hydraulic	1	83	0	0	
18	Traverser overhead	1	2,446	0	0	
19	Shafting with couplings		2 860	0	0	
20	Cost of erection of the above machines		2 894	0	0	
21	Cost of miscellaneous tools supplied to Boiler Shop		12,000	0	0	
	TOTAL Rs		43 842	0	0	

S I R Workshops—Subject 15

I em No	DESCRIPTION	No	Approx ma e va ue.	Remarks.
	Tool Shop—*continued*		R a p	
	Brought forward Rs		89 307 0 0	
39	Lathe wheel narrow gauge	4	14 237 0 0	
40	1 6¼" centre	4	2 232 0 0	
41	broad gauge 3 8"	2	12 756 0 0	
42	2 3"	1	4 418 0 0	
43	s ngle geared brass fin sh ng 7" centre	1	644 0 0	
44	brass fin sh ng 5" centre	1	42 0 0	
45	turn ng self act ng 12½" centre	1	1,465 0 0	
46	double geared 9½" centre	2	1 550 0 0	
47	axle	1	1 777 0 0	
48	double end tu n ng complete	1	532 0 0	
49	geared w th sh ft ng bed plate 11" centre	1	2 420 0 0	
50	gap self act ng 9½ centre	1	1 500 0 0	
51	sl d ng, surfac ng and screw cutt ng 12" centre	1	3 338 0 0	
52	10"	1		
53	7"	2		
54	gap and screw cutt ng 6"	1	700 0 0	
55	10"	1	1 900 0 0	
56	double geared self act ng sl d ng surfac ng 16" centre	1	2 285 0 0	
57	self act ng s d ng and surfac ng 18" centre	2	12 735 0 0	
58	screw cutt ng 10½" centre	1	1 450 0 0	
59	6 "	1	700 0 0	
60	9½"	1	1 500 0 0	
61	7 "	2	1 652 0 0	
62	bor ng tyre	2	4 250 0 0	
63	lapp ng	2	200 0 0	
64	nut fac ng	1	530 0 0	
65	Crane j b w th travers ng act on	1	1 000 0 0	
66	*3 ton t ave l ng*	1	2 763 0 0	
67	Emery tool gr nder patent 1 8" d ameter	1	647 0 0	
68	3	2	2 482 0 0	
69	Templa e Wh tworth and standard T plate bor ng boxes	2	800 0 0	
70	Traverser overhead 10-ton	1	4 860 0 0	
71	Stand p pe and pump complete	1	500 0 0	
72	Shaf ng and pu eys w h plummer blocks complete		11 865 0 0	
73	Cost of e ec on of the above mach nes		18 923 0 0	
74	Cost of m scellaneous tools supp ed to Tool Shop		16 000 0 0	
	TOTAL Rs		2 24 160 0 0	

S. I. R. Workshops—Subject 15.

Item No	DESCRIPTION	No	Approximate value R	a	p	REMARKS
	Boiler Shop					
1	Engine, stationary with boiler . . .	1	13 066	0	0	
2	Machine, punching washers and cutting round iron .	1	104	0	0	
3	„ punching and shearing . .	1	1 592	0	0	
4	„ shearing hand	1	889	0	0	
5	„ drilling . .	2	1 680	0	0	
6	wall drilling . . .	1	603	0	0	
7	cutting tube	1	342	0	0	
8	„ cleaning tube . . .	1	200	0	0	
9	„ bending plate . .	1	1 871	0	0	
10	sawing hot iron .	1	797	0	0	
11	„ tube swaging, made in shop	1	20	0	0	
12	weighing . . .	1	243	0	0	
13	Crane for smith fires	2	340	0	0	
14	Forges portable . .	15	1 500	0	0	
15	Grindstone with trough	1	40	0	0	
16	Pump test complete	1	272	0	0	
17	Punches hydraulic . . .	1	83	0	0	
18	Traverser, overhead . . .	1	2,446	0	0	
19	Shafting with couplings .		2 860	0	0	
20	Cost of erection of the above machines		2 894	0	0	
21	Cost of miscellaneous tools supplied to Boiler Shop		12 000	0	0	
	TOTAL Rs		43 842	0	0	

S I R Workshops—Subject 15

Item No.	DESCRIPTION	No.	App ox mate value	Remarks
	Smith Shop		R a p	
1	Blo ver Root s patent	1	2 657 0 0	
2	Bo ler small for d tto	1	500 0 0	
3	Machine swag ng bolt maker	1	1,035 0 0	
4	„ bolt maker Ol ver s	1	50 0 0	
5	„ bolt mak ng	1	50 0 0	
6	„ bolt and nut forg ng Horsefall s	1	6,018 0 0	
7	spr ng test ng	1	2 767 0 0	
8	„ we gh ng	1	243 0 0	
9	Hammers, steam 5 10 and 15 cwts	3	6 163 0 0	
10	Crane	1	1,000 0 0	
11	Crane for sm th fires	14	700 0 0	
12	Furnace tyr ng large	2	1,400 0 0	
13	spr ng	1	500 0 0	
14	case ha den ng	1	200 0 0	
15	Trough spr ng hardening	1	300 0 0	
16	fi e	2	500 0 0	
17	Hearth portable for stra ghten ng ax es	1	200 0 0	
18	Pumps hyd aul c	3	2,076 0 0	
19	Gr ndstone w th trough	1	192 0 0	
20	Cost of erection of the above mach nes		2 695 0 0	
21	Cost of miscellaneous tools supp ed to Sm th shop		18,000 0 0	
	TOTAL Rs		47 647 0 0	
	Foundry *(Including T nker Copper Sm th and Pattern Shop*			
1	Eng ne stat onary	1	2,000 0 0	
2	Machine fan blast	1	310 0 0	
3	mou d ng for ax e boxes	1	316 0 0	
4	We gh ng mach nes	2	486 0 0	
5	Cupolas wrought ron	1	1 500 0 0	
6	Forges portab e	1	100 0 0	
7	Crane	1	1 095 0 0	
8	Cost of e ect on of the above machines		600 0 0	
9	Cost of m e aneous tools supplied to Foundry		19 000 0 0	
	TOTAL Rs		25,607 0 0	

S. I. R. Workshops—Subject 15.

Item No	DESCRIPTION	No.	Approximate value.	Remarks.
	Erecting Shop.		R a p	
1	Machine, cylinder boring	1	300 0 0	
2	" steam port facing	1	350 0 0	
3	" weighing, portable, Ehrhardt's patent	8	1,224 0 0	
4	Crane, steam	1	6,831 0 0	
5	Pump, hydraulic, testing boiler	1	280 0 0	
6	Traverser, overhead, 20 tons each	2	11,745 0 0	
7	Cost of erection of the above machines	.	2073 0 0	
8	Cost of miscellaneous tools supplied to Erecting Shop	...	17000 0 0	
	TOTAL Rs		39803 0 0	
	New Tank House.			
1	Engine, steam pump, Tangye's with boiler	1	1840 0 0	
2	Engine, steam, fire	1	2,420 0 0	
3	Cost of erection of the above		426 0 0	
4	Cost of miscellaneous tools supplied to new Tank House	..	50 0 0	
	TOTAL Rs		4,736 0 0	

drawing which I enclose* such a nozzle is shown I may add that the thread of the screw in the union at one end of it is shown as six threads per inch This represents a very old practice on many state railways extending back some 20 years, but the latest con tracts for washout apparatus specify such threads to be of the London Fire brigade stand ard without quoting the number per inch Measuring them however, they are about five per inch I think this is a matter which should receive attention, and that the number of threads per inch should be distinctly mentioned in each contract, as the variation between those in use out here and those now being sent out causes great inconvenience

This letter was forwarded with the drawings to the Director General of Stores at the India Office, and the following report by the Consulting Engineer was received in reply

In these papers the Locomotive Superintendent criticises the standard design of washing out apparatus and proposes certain alterations I am not prepared to say that the existing pattern is perfect, but it has many good points and has been in use for a long period on a great many lines without complaint of it

Points like these ought to be considered at the annual conference of Locomotive Engineers before they come home.

* Not reproduced.

MINERAL OIL TANK WAGONS—SUBJECT 5 A.

Eastern Bengal State Railway; 5 ft 6 in Gauge

By Mr A S Jameson

I forward herewith a ferrotype of an Oil Tank Wagon designed to carry 17 tons of Kerosine oil (*see plate LIII*). This wagon was the outcome of a demand for an increase in carrying capacity against wagons carrying 9 16 to 9 17 tons only with a tare of 8 tons 15 cwt It was also desired to retain, if possible, the same class of wheels and axles and remedy a very grave defect in the original wagons *viz*, the attachment of the tank to the frame This originally consisted in rivetting the one on to the other, leakage at the rivets, after being in use a short time, resulting

In the design submitted, in order to secure such a large carrying capacity and keep within the limit of 1 2 tons per foot run over buffers, it was necessary to place 6 wheels under, and thus not only were the same class of wheels and axles adhered to as in the original wagons, but also the same class of springs, axleboxes, brasses and axleguards

The tank, it will be observed, while quite independent from the frame, is firmly secured thereto by means of straps going right round the tank, the ends being bolted to brackets on the underframe, and tie bars running diagonally from the centre of the frame to the back of tank, where they are secured to pieces of channel iron

Two gussets ¼ inch thick, reaching half way up the wagon, have been inserted to give additional stability and break the force of the oil against the ends of the tank should it be at any time partly empty, and two diaphragm plates also ¼ inch thick have been inserted for the same purpose

The bottom T irons have been arched at intervals to admit all the oil draining out thoroughly To further facilitate this draining after the wagons have been pumped out, the drawing off cocks have been placed to draw from the centre of the tank at bottom with a good fall from the sides and ends.

Two rotary pumps have been placed on a platform at one end of frame, experience having gone to shew that this is the best and most convenient position Originally a pump was placed on the top, where it was found to be out of place and much exposed

E. I R Mineral Oil Tank Wagon—Subject 5 A

East Indian Railway; 5 ft 6 in Gauge

By Mr R Pearce

The rivetted rectangular wagons sent out from England give great trouble in leaking at the joints, and are constantly requiring attention in the shops The cylindrical form was therefore selected, made of Fox's Patent pressed steel, no joints and no rivetting below centre of tank (*see plate LIV*). It was intended that the plates should be ¼ inch thick, but on enquiry it was found that there would be a difficulty with anything less than $\frac{5}{16}$ inch plate

The two diaphragm plates $\frac{3}{16}$ inch will be put in before the cylinder is welded up

The cylinder rests on four semi circular bearers rivetted to underframe, firmly held down by straps, the bearers being secured to each other and to the end brackets with angle iron cross bars and by longitudinal tie-rods, the whole forming a secure job, and covered with corrugated iron of No 24 B W G for protection

The hand rotary pump should be capable of emptying the tank in 1½ to 2 hours I have not specified any particular pump, there are so many to select from in England

The underframe to be made of Fox s Patent pressed steel

Tare of wagon	9 0	tons
Load do	15 0	„
Total	24 0	„

Cylinder 22 6′×6 3″ diameter, of 690 cubic feet capacity

The wheels, axles, springs and draw gear to be of standard pattern for Indian Railways. The axleboxes of Fox's Patent pressed steel

Twelve tank vans to this specification and drawing are in hand building by the Leeds Forge Co, England and are expected shortly The estimated total cost of vans in India at exchange of *1s 1½d* is R4 509 each

M R C Mineral Oil Tank Wagon—Subject 5 A

Madras Railway, 5 ft. 6 in. Gauge.

By Mr C E Phipps

The wagons we use are built to the drawing enclosed (*see plate LV*) The tanks of the wagons built hitherto are 15 feet long over all and 7 ft 1 in by 5 ft 4½ in in cross section and hold 11 tons of oil when full We are also at present building a wagon of exactly similar type, excepting only that the tank is 7 ft 2 in high instead of 5 ft 4½ in as in the smaller ones, and this when finished will hold 15 tons of oil

I adopted the section shown for the tanks, as I considered it better than the cylindrical section, it enables the centre of gravity to be brought lower down on the wagon, and it is further, in my opinion less liable to distortion than a cylinder would be when partially filled only A good deal of care has to be taken in rivetting the tanks up and in caulking to ensure a thoroughly tight job, but this having been once done no further trouble has been found, and the wagons we have are as tight as possible, though they have been in continual use for over 2 years

The man hole cover joint is made by a leather ring between the turned faces of the cover and is screwed down by set screws and clamping bars passing through wrought iron straps fastened to the seating The centre clamping bar is further fastened by a pin and forms a hinge, and being fitted with a padlock enables the cover to be secured The wagons are all built upon standard iron underframes, and the tanks are lagged with galvanized iron sheets which are set back by wrought iron distance pieces from the tank plates so as to allow a current of air to pass in between the lagging and the tank

S I R Mineral Oil Tank Wagon—Subject 5 A

South Indian Railway; Metre Gauge.

By Mr C. E. Crighton

In Madras during the last few years the transportation of Petroleum oil in bulk has assumed large proportions Steamers specially fitted with tanks bring the oil in bulk to the Port of Madras, and it is pumped from the vessel into large receiving depôts at Rayapuram, whence it is conveyed by rail over the South Indian and Madras railways in specially constructed oil tank wagons to various towns in the Presidency.

On the South Indian Railway, ten tank-wagons, each of a capacity of 10 tons, have been constructed for the carriage of Petroleum oil in bulk (*See plate LVI*)

The oil tanks are carried on an iron underframe 21' 5" long over head stock plates, and 25' 0½" long over buffers with three pair of wheels 2' 4" diameter and journals 7" × 3½" The wheels are spaced 6' 0" feet apart

The oil tank, which is somewhat oval in shape, is constructed of ¼ mild steel plates with suitable longitudinal and transverse stays, and has a large dome provided in the centre of the top for filling, with a close fitting hinged lid which can be locked, inside the dome there is a strainer to prevent dirt or foreign matter entering the tank. On the underside of the tank immediately below the dome the discharge valve is fixed, and this valve can only be operated from the inside of the dome when the lid is opened From the underside of discharge valve, the oil is conveyed in pipes to either side of underframe where suitable racking cocks are provided for filling oil drums at wayside stations At one end of the wagon frame a force pump is fixed for pumping the oil into large reservoir tanks at important stations

As petroleum oil is very searching, all joints and seams have to be very carefully made and caulked the tanks are tested under hydraulic pressure of 10 to 15 lbs per square inch, and along the seams, and rivets inside are coated with Messrs. Halzapfel and Co s petroleum-resisting composition, which makes all perfectly tight and free from leakage of any sort

The tanks are constructed to hold 2,750 gallons, which at 8 lbs 2½ oz per gallon of Petroleum is equal to 10 tons capacity

The tare weight of each oil wagon complete is 7 tons 12 cwt

The tank is encased with corrugated iron sheeting with a good air space allowance to prevent the heat of the sun raising the temperature of the oil and the chance of sparks lodging about the tank

Brakes are not provided on these wagons to avoid the risk of heating and sparks.

REVISION OF GENERAL RULES.

Copy of Government of India, P. W. D., No 137 R. S, dated 8th May 1895

I am directed to forward, herewith, a corrigendum slip to the above mentioned rules circulated with Government of India Resolution No 353 R. S, dated the 16th October 1894, and to request that the corrections and additions contained in the slip may be carried out as therein indicated

2 I am to say that the alterations in the rules have been made with a view to giving the members of sub-committees a better opportunity of considering their reports during the interval between two general meetings, and that the Government of India desire to take this opportunity to express their appreciation of the good work hitherto done by the Committee of Locomotive and Carriage Superintendents

Corrigendum Slip.

Rule 4—For the words "*for one year*" read "*till the next general meeting*"

Substitute the following for Rule 8 —

8. "The meetings of the committee may, with the approval of the Government of India, be held not oftener than once in two years The word 'meeting' shall be held to mean the entire period during which the members of the committee are assembled in one neighbourhood for the purpose of transacting business.'

Rule 9.—For the words "*an ordinary annual*" in the first line read "*a general*"

Rule 10—In the last para. of this rule for the word "*annually*" read "*periodically*" and add the following *as Rule* 10 (*b*) —"In years when no meeting is held the Secretary will issue an ad-interim report, showing all standards agreed to by ballot vote since the last meeting."

Rule 13—*Add the following at the end of this rule* —

Copies of the ad-interim report will be issued in accordance with para 4 of Government of India letter No 284 R. S, dated the 18th August 1894.

Rule 14—In the second line for the word "*annually*" read "*periodically*"

NOTE —The above corrections have been carried out in the Rules printed at pages 7-9 in this volume.

CORRESPONDENCE BETWEEN THE CONSULTING ENGINEER AND THE CHAIRMAN.

Copy of a letter, dated Calcutta, 22nd March 1895, from Mr. J. R. Bell, Consulting Engineer to the Government of India for State Railways, to Mr C T. Sandiford, Chairman of the Committee of Locomotive and Carriage Superintendents

1 There is some justice in the desire for a larger recognition of its services by the Locomotive and Carriage and Wagon Committee, and the time is nearly due for presenting a review of its results to the Government of India I should first, however, be glad to hear from you and it on what follows.

2 Much earnest and skilled effort has clearly been devoted to the subject of improving the efficiency and uniformity of motive power and rolling-stock, in the five years of the Committee s existence There is ample evidence, both in its proceedings and outside, that its labors have enlarged the scope of individual experience, but I think it must be admitted that the results show a larger tendency to divergent practice than was expected

3 Whether that result is to be regretted or simply accepted remains matter of opinion It arises primarily from the peculiarities of a race which justly attaches vast importance to individuality, it is fostered by disparity of local circumstances, by the paramount necessity of using up existing appliances, and in a measure by a degree of emulation not always co-ordinated to the needs of other Departments.

4 In some points of detail diversity of practice is, I venture to suggest, unnecessarily marked. No two lines appear to even concur as to the distinguishing mark on vacuum braked vehicles, or the significant lettering of stock, and one line's "A" may be another line s "L"

5 Another matter which gives me personally some disappointment is the paucity of effort towards explaining or even analysing the great disparity which obtains between working expenses on even neighbouring lines though such matters as the effect of grades, weather, cost of stores and of labor, etc , are, I hope as easily reduced to figures here as in, say, Belgium

6 It is your proposals, however for improving covered goods stock that I fear are least satisfactory Years ago we had wagons which tared under 6 tons and carried 12 on 13½ square feet of floor to the ton Only a few days ago Mr Dod informed me you had matured a design to carry over 17 tons on a tare or under 7 But this I now find turns out, when built, to tare nearly 8 and carry 16 tons on 11 square feet per ton If, as I do not doubt, this is a correct statement of the facts, we are exactly where we were in ratio of tare to maximum load, worse off in ratio of tare to average load , for the same tare we shall have 3 wagons in place of 4, and some of the 3 will still by rules run through to destination with but 3 tons of paying load. As far as I see, our average loads have at best increased by one ton for each ton of extra tare, so that there is a distinct loss with heavier wagons on lines with much light running If, when Mr Jones increased metre gauge wheels from 2 feet to 2 feet 4 inch diameter, he introduced a paying economy, our increasing journals from 4 inch to 4½ inch is economy reversed in the matter of journal friction as well as in handling bulky goods.

Correspondence between the Consulting Engineer and Chairman.

7 It seems to be still assumed that the requisite strength of buffing and draw-gear depends on the weight of the train, not that of the wagon, but it is far from clear that the bill for damages done in shunting will verify this assumption When all is done, maximum loads will prance along the rails with 33 per cent more weight carried on 33 per cent. stiffer springs, and consequently, I imagine 44 per cent more *vis viva*, in hammering the road, so that if I am not much mistaken, our reform in this particular still needs some justification

8 As to engines, if I may make bold to say so, it is far from clear that our newer lines and newer designs are as cheaply worked as some of the older Progress is the order of the day and in the four coupled class alone, for instance, the advance from the "H" class of the Indus Valley to the new East Indian railway express engine is immense It is far from clear, however, that all the permutations of design from the East Indian railway to Eastern Bengal, Bombay, Baroda and Central India Great Indian Peninsula, Nizam's Guaranteed State railway, and I know not how many more new variations of this one type are all necessary or desirable Though I quite agree that there is no material advantage in detailed uniformity between different lines still I personally greatly commend Sir A M Rendel's general views, and, while I doubt with him if India is yet the place to mature designs of engines in,'I strongly commend the concentration of effort on getting one good type of express—one mixed, one goods and one ghat class of engine It is right to tell you here that very competent administrations tell me that a vast sum is locked up in duplicate parts of engines which could be largely reduced if you had fewer types This is clearly a point for your Committee to deal with, and another which has lately come to my notice, *vis*, that allowing for the greater number of engines under repair, an appreciably smaller number of tenders will do to carry on work with If duplicates cannot be dispensed with it is by no means clear that their purchase cannot be at least postponed, or that more could not be made up as required in the country, while such things as cranked axles must, I fear, be equally largely supplied whether our types be many or few

9 I strongly commend what you may find occasion to answer in the above to your *careful consideration, and with the assurance, which I hope is not necessary, that these* views are offered in no mere spirit of cavil

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Copy of reply from Mr C. T Sandiford, dated Lahore, 5th April 1895.

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1. I am afraid that a certain amount of disappointment is certain to be felt by any one studying the proceedings of the Locomotive and Carriage and Wagon Committee. A good deal is naturally expected from a body who have devoted their lives to a specialty Much time was at first spent, and I suppose necessarily so in regulating the conditions under which business could be conducted, and it was not all at once that men unaccustomed to have their practice criticised, and who had always exercised a large measure of independence, fell into and saw the advantages of consolidated designs But perhaps the greatest barrier of all was the fear that the acceptance of an improved design might result in loss to the lines agreeing to it, representatives were consequently slow in subscribing to anything which might commit them to alterations of existing types Notwithstanding this, I feel satisfied the meetings have effected an immense amount of good, and done much to rub off those angularities which prevent cohesion, and at each meeting I saw a greater disposition to coalesce

2 The comparative isolation that formerly existed, explains the great divergences of opinion found among men who had previously little intercourse—it was to be regretted Yet, admitting the call to use up existing appliances and to conform to Standard to whic

a particular line was largely committed, there is still most unquestionably a great deal due to individual ambition which leads men to design something different, not so much because it is greatly better, as that it is identified with the producer (This may be disputed, but an impartial examination will prove it) The numerous small diversities found in the practice of different railways are altogether unnecessary, and nothing can be said in their favour

3 The entire absence in the proceedings of anything like explanation for the differences in working expenses, referred to in paragraph 5 of your note is, I believe, accounted for not because there is no material available (the analysis of working and statistical tables hold an enormous mass of detail), but because the Committee as a whole never had time to go into the matter, while the individual members have scanty leisure, much of their time being frivolled away in routine every day duty

4 The proposals for improving Goods Stock took the question up at a fairly advanced stage The old six ton wagons taring about $5\frac{1}{4}$ tons, had in the best practice become ten tonners, taring 6 tons to $6\frac{1}{2}$ tons and in some cases had even without any great increase in tare been *marked* to carry $12\frac{1}{2}$ tons ! on a floor area of $13\frac{3}{4}$ square feet per ton, so that the new design taring as it does $7\frac{1}{4}$ to $7\frac{3}{4}$ tons to carry a maximum of $16\frac{1}{2}$ does not really show much advance, the only material difference is, that it is a good deal stronger, includes the extra weight of military fittings, and costs less in repairs As to the advantage or otherwise of providing wagons of such heavy tonnage I am afraid it is one of those economic questions which were sunk in the struggle to do better There can be no disputing the fact that for small and moderate consignments the old wagon was the preferable vehicle The objection to vehicles with a large loading margin, is of course, always present with springs and other parts which if strong enough for the full load, are unnecessarily heavy for the half or even smaller loads

5 I am so much in accord with you in what you write about engines, that I can say no more than that I endorse it unhesitatingly Provided a suitable design which has been matured is available, we should be very chary indeed to add another to the list There are of course considerations which mostly indicate the description of engines required, but I have often thought, and still incline to the belief, that India generally, and many lines in particular, would have profited had there been one common Controller, and it would have ensured uniformity and consistency ! Judging by what we see, there is little more of either than is found in dress, but I suppose it must be put down to the individual idiosyncrasies always found among Engineers

APPROVED DESIGNS OF LOCOMOTIVES—SUBJECT I
NOTE BY THE CHAIRMAN.

Note by Mr C Sandiford dated Lahore 25th April 1895, with reference to correspondence published at page 125 of this volume

I have the honor to offer the following remarks on the Consulting Engineer's note dated 2nd November 1894 —

2 The Consulting Engineer attaches a value to the diagrams which the Committee of Locomotive and Carriage Superintendents carefully safe guarded against and hoped to have made clear under rule 18 *

3 The great object of the Committee, as stated, is to reduce to some sort of order the heterogeneous collection of Engines and Rolling stock which has from time to time been launched on us from home for use in India, much of it suitable enough when originally sent, but a great deal of which has become antiquated through time and altered conditions, it is not, however, to be expected that in a few meetings any body constituted like the Locomotive and Carriage Superintendents' Committee could correct the peculiarities of 30 years scattered over 20,000 miles of Railway

4 The Consulting Engineer twits members of the Committee with disagreeing to the extent of sending him designs differing from existing engines and each other Nothing is more likely, but the real point to decide is, and I expect the Consulting Engineer in his responsible position exercises his judgment to the full,—*Are the proposals suitable for the work on the particular system for which they are requisitioned? And has the design been matured with a view to uniformity on the Railway for which it is intended?* At the very outset it became evident that the Committee were generally of opinion that it was on the whole more advantageous for a Railway requiring additional stock to follow some type of engine already on the road with a view to the enormous convenience and economy due to the component parts being alike, than to go in for a totally different type!

5 The idea that there would be any advantage in keeping engines in Southern India like those in the north was never admitted. To small and new lines, this, of course, does not apply, and there is no reason why on the East Coast and other new lines we should not have the very best and most suitable locomotives In these cases there is seldom a Locomotive Superintendent to meddle in the matter at all yet, judging by results, we do not seem to have greatly profited

6 I, and I believe, other members of the Committee altogether dissent from the general imputation, that we consider the Consulting Engineers are all more or less wrong, we think nothing of the sort, a great many of the engines sent out to this country have done excellent work on the service for which they were originally designed, and compare favorably with the best in any country but the conditions in many cases have very much altered, heavier loads and higher speeds are now demanded, and the engines that were sufficient are now not capable of the greater duty demanded, the very same thing has taken place at home It is not the Consulting Engineers or Locomotive Superintendents who are responsible for this, it is the public who clamour for faster and more punctual service,

* Old Rules Section 6 (r) of new By laws

and the general belief, that in the case of goods traffic, heavier loads are more economical which has led Traffic Managers to run bigger trains.

7 To show that the call for alterations in type is not due to the vagaries of Locomotive Superintendents, or to the shortcomings of our Consulting Engineers, but to the new demands which are made on us for power, I will put the case of the line, with which I am connected, forward as an example

8 When the North Western Railway was constituted, nine years ago, out of a stock of 435 engines, there were no less than 18 types of engines on the road, collected from all parts of India, differing in almost every conceivable direction, many of them the outcasts from other lines, designed for very different work

9 We now have 588 engines on our books and have reduced the number of types to 7 including 20 engines of a very special type for the Upper Bolan, 17 old passenger engines of small power, and 17 six-wheel coupled engines of an early pattern, both these are off the Great Indian Peninsula Railway, none of the three last types in their present form are likely to be perpetuated But the six-wheel coupled engine as improved on Great Indian Peninsula Railway has developed into a locomotive of the class we want, it is, however, now very different from the 17 we have on the North Western Railway Looking at the remaining 4 types, which from their age and the number of each which we have, we must continue to run for many years on North Western Railway, I offer the following remarks on each —

10. The 'L' class engine, of which we have 220 as last supplied to North Western Railway although, in the main, a good engine for the particular work for which it was designed years ago, has the radical defect of being very low in adhesion, this defect was partly remedied in last engines, but for heavy work is still much too low, the failing cannot be eradicated without considerably altering the design, yet it is practicable and worth considering for it is effected in the new Highland goods engine, which is more or less a copy of the "L" class The staying of the fire box is also very defective, tubeplates have to be removed at very great cost and inconvenience before they are quarter worn out, in a new engine this could easily be remedied, and it should. This engine, designed as it was for heavy grade work, is not particularly suited for main line goods traffic it is too slow It should have the size of wheels increased with these modifications the engine would do well But to effect them differs little from a new design, although we might still call it an 'L" class

11 The H & H. B class engines, of which we have 160, also designed over 20 years ago for a much lighter traffic than we now run, have done very well particularly on mixed trains, but are now so clearly over taxed that no one would think of ordering more for our traffic on the North Western Railway To increase the power of the engine is nothing short of a new design Our four wheel coupled K S class of which there are 113 is the survival of an S P D R type, has proved itself a first class engine, and had not the weight and speed of trains been increased would leave nothing to be desired But to make it more powerful as in the case of the H & H B, means a great deal of alteration and additional weight, and practically means a new design

12 The fourth and last group "P class," also a four-coupled engine, has given excellent results, a later design than any of the other engines, more nearly conforms to the present requirements and is easier to modify, if needs be

13 From what I have stated, it will be seen that the bulk of our Locomotives are embraced in four big classes, and for the work they were designed for, are not condemned, on the contrary, did the work well, but the demand for a higher duty forces Locomotive

Superintendents to look ahead Although, I do not pretend to know all the circumstances, I assume that what has occurred on the North-Western Railway, has happened on other Railways and am confident, that on the main trunk-roads, it must have done so, while smaller systems are not less *ambitious*

14 I appreciate at the full the Consulting Engineer's protests and objections to change and do not think he asks anything more than is fair and reasonable he should be given substantial reason for any radical change of design So far as I am personally concerned I have always been most anxious to reduce the number of different types, and have for years laboured to do so, and believe I can point to the results as substantial proof of my sincerity

15 At the present time the North-Western Railway, I believe, wants a thoroughly sound six wheel coupled tender engine for main-line heavy goods traffic, and I am of opinion, that the reasons which govern its selection are found in the importance of conforming to practice found on this Railway, and are not ruled by the idea that it will profit the North Western Railway to get engines like those intended for somewhere else

16 We want an engine that will haul at a fair pace for goods traffic 1,000 tons (excluding engine and tender) over a ruling grade of 1 in 186 Was there time allowed (and there is no good reason why there should not be) a preliminary discussion on proposed new designs would do much to clear the way to satisfactory progress I certainly would be glad to be given such an opportunity in the case of the new engine now required

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

PART IV.—SELECTED PAPERS

CALCUTTA.—DECEMBER 1894.

COMMITTEE OF

LOCOMOTIVE AND CARRIAGE SUPERINTENDENTS.

SELECTED PAPERS. 1894.

THE HAGANS COUPLED BOGIE LOCOMOTIVE.

Reprinted from "Engineering," dated 28th December 1894

The Locomotive fabrik Hagans, of Erfurt Prussia make a speciality of bogie Locomotives with four coupled axles for railways of all gauges with steep gradients and sharp curves The engines are supplied with two or more cylinders fixed to the engine frame and may be constructed for any type of railway The points of most interest, the suspension and driving of the bogie, are illustrated by figures 1 to 3 plate LVII The two cylinders are fixed to the main frame Of the two pairs of coupled axles the front pair A_1 and A_2 has its bearings in the main frame the other pair, A_3 and A_4 in the bogie frame The piston transmits the power in the ordinary way to the crosshead, connected by a short rod *a b* (Fig 1) to the front lever *b d* centered in the main frame The connecting rod *b f* and coupling rod *f e* communicate the motion to axles A_2 and A_1 Another coupling rod *c h* leads over to the rare lever *i g* centered in the upper part *g* of a sort of cradle *g k* It is clear that, with equal leverages, the extremities of the two levers, *b* and *i*, will always describe the same arcs The two bogie axles receive their motion in the same way as the front pair by means of the connecting rod *i p* and the coupling *p q* The connections are the same on the other side of the engine, the one crank having the usual lead of 90 deg The four axles thus revolve with the same angular velocities The pin *n n* of the cradle *g k* fig 2 has its bearing in the main frame the rod *k o*, connected at *o* with the bogie frame, holds it in position The point *o* lies in the centre line of the axle, and may be constructed either as a counter crank or as an arm rigidly fixed to the bogie frame Of course, as the engine goes round a curve the distance between the centres of the front and rear wheels will be increased on one side and decreased on the other and provision must be made for this For this reason the link carrying the pins *h* and *i* is not fixed rigidly to the frames but is carried in a second swinging frame as shown in fig 1 The lower end of this frame is coupled by a rod to a point *o* fixed on the bogie, and when the engine rounds a curve this rod tends to tilt the swinging frame into the position $g^1 n\ k^1$ on the inside of the curve and to an opposite angle on the other side In this way the difference in the length of wheel base on the two sides is taken up

In fig 3 the engine has passed on to a curved track The cradle has turned and points *g o k* have assumed the positions $g_1\ o_1,\ k_1$ If now *p* and *o* had the same distances $z = s$ from the axis, the following ratios would be equal —

$$k g \quad n g = i g \quad h g = b d \quad c d$$

But, for constructive reasons z has to be made larger than *s* and the respective deflections of *o* and *p* result from the proportion $v\ \ y\ \ \ s\ \ x$ The extremity *h* of the rear lever would, however, on a curved path not retain its position unless we make $\frac{gn}{x} = \frac{nk}{v}$ In that case points *g p i* undergo the same deflection and gg^1 becomes equal u_1 that is to say, equal movements in opposite directions are imparted to the extremities *g* and *i*, so that the point *h* will not swerve, and the engine runs thus true on a curved track.

Hagans coupled bogie Locomotive.

It remains to be proved that there shall be no reeling of the bogie The horizontal force H transmitted from s to p acts also upon $g\,s$ and upon $g\,k$ As now $g\,h = h\,s$, the point o will receive from y the component $\frac{x}{y}H$, and the bogie will be subject to a couple, $M = H\,s - \frac{x}{y}H\,v$ As, however, $\frac{x}{y} = \frac{s}{v}$, and therefore, $Hs = H\frac{x}{y}v$, M will always be zero Part of the pull communicated to the bogie will, under these circumstances, be transferred back to the main frame.

The points o, k, j, p have to describe a curve in the horizontal plane This might be managed by means of a ball and socket joint, but Mr Hagans prefers his own bearing fig 4 the bushes of which have the form of an upright cylinder bevelled on two sides The bearing is said to give complete satisfaction, it can easily be adjusted As regards practical experience, Dr Pfahl, of the Bieber Coal Mines, near Frankfort-on-the-Maine speaks well of the two Hagans locomotives running on a private line, joining the mines to Gelnhaunsen station The line is 13 miles long, has gradients up to 1 in 40 curves of 40 yards radius, and a gauge of 35 4 in Mr Pfahl originally used engines with three axles, of about 100 horse power This power became insufficient Much heavier engines were out of the question The feed water could only be taken at one of the termini at the end of a return trip of 27 miles. The boiler had to hang low, and no lateral projection could be permitted To meet these requirements Mr Hagans supplied this special locomotive It weighs, with charge, 28 tons,—about a third more than the old engines It can take 770 gallons of feed-water against 500 in the former engines, and pulls about 144 tons, with an average speed of 11 miles, against 96 tons The cylinders are 13 in in diameter by 14 in stroke, the diameter of the wheels is 29 5 in The distance between the two front axles is 55 in, between the two axles of the bogie, 31 5 in total distance between the first and the fourth axles, 10 ft. The engine has 560 square feet of heating surface and 9 square feet of grate area, and works with a pressure of 170 lbs The engine runs steady, both forward and backward. Mr Pfahl was perfectly satisfied, and soon ordered a second locomotive of the same type.

THE POWER AND EFFICIENCY OF LOCOMOTIVE BOILERS

Reprinted from "Railroad Gazette" dated 29th March 1895

In another column a correspondent asks about the arguments for and against large grates for locomotive boilers To reply fully would take much space, as the theories offered do not harmonise, and in many cases differ from the facts

Although the arguments about the best forms of fire boxes for boilers that are run with forced combustion conflict with each other and often are contrary to common sense, it is not to be understood that there is no ground work of fact that is accepted by all who are fair minded With these facts well in mind, one will at least not be led into follies and he may escape some mystification About combustion there is no mystery If coal is heated in contact with air there will be combustion and when the heat is sufficient and the air supply is correct there will be perfect combustion We know how much air it takes and how much heat is required and knowing this, it is one of the easiest of mechanical operations to get perfect combustion If perfect combustion was the prime object of burning coal we could get perfection at once

But we do not seek perfect combustion or anything like it perfect combustion is too expensive The last few heat units cost more to save than they are worth We do seek to get the most heat into the water in the boiler that can be got from a pound of coal under some given set of conditions and generally it is found that these conditions are such that anything like perfect combustion is impossible This is true of a locomotive firebox

In a locomotive boiler the first restriction to perfect combustion is the necessity of providing an absorbing surface, and an absorbing substance (water) that will take up the heat If the space and weight of a locomotive boiler could all be given to the furnace we could get better combustion than is obtained in any class of boiler to day But the space taken up by the heating surface and the water is so great that the furnace is cramped and reduced to the lowest possible limits—in fact, there is less room for combustion in a locomotive boiler as these boilers are forced in this country, than is allowed for combustion in any form of boiler used, except those for fire engines and torpedo boats, where power, and not economy, is the thing sought. In locomotives both great power and good economy are wanted and that is where the "shoe pinches We could easily get one, but to get both is impossible

The best that can be done is to select by trial the boiler and furnace so that the best practical results are obtained No amount of theory unless guided by practical experience, will tell what to do to get the best locomotive boiler There is, in fact, no such thing as a best locomotive boiler for all the different conditions The best practical boiler for a road where the fuel is cheap and good is the one that will give the most power without regard to the efficiency unless the efficiency is so low that the boiler has to be forced so that the sheets are damaged and the repairs are too much increased Where fuel is very cheap power is the thing most wanted and that boiler which will give the most power for the hauling of trains will be the most successful The limit to the reduction of efficiency in the search for power alone is found in the loss of power which follows when the efficiency is very low

Power and Efficiency of Locomotive Boilers

When coal is high in price the need comes of an economical boiler, and the power must be reduced, or the cost of hauling a ton one mile will be higher For this reason the train load is made less and the boiler is forced less, and is more economical In this country we have cases of both kinds. Coal varies in price from 80 cents to $ 20 a ton. The boiler that is fitted for the use of the $ 20 coal is just as serviceable for the 80 cent coal, so far as the efficiency of the boiler alone is concerned But when the whole cost of transportation is taken into account, it is found that the final cost per ton mile is less when the engine hauls the largest train, and therefore the most powerful boiler is the one that it is best to use It is for these reasons that it is necessary to know the conditions of operation before the best boiler can be selected

All know how to get the most economical boiler and how to get the most powerful boiler But we may state the difference in a general way The most powerful boiler is had when the grate is as large as possible and the crown sheet is not too far from the fire, and the tubes are about 10 or 11 feet long and large in area of opening, so as not to impede too much the passage of the gases A 2½ inch or 3 inch tube will give more power than a 2 inch tube The blast must be as strong as is possible to get it and not raise the back pressure in the cylinders too high, and there must be a variable exhaust so that the fire shall not be torn up at starting, otherwise the power will be lowered Such boilers are used here, and they are capable of furnishing, regardless of economy, all the steam that can be used in a locomotive

The most economical boiler must have just as large heating surface as possible, especially in the fire box, and the combustion must be slower, or there must be some better means than we now have for getting the air to the fuel. The mere passage of the air through the fuel is not an adequate mixing when the rate of combustion is high and good efficiency is wanted This is the reason, above all others, why forcing a boiler reduces the efficiency, and it is the reason why a small grate, which has to be forced, will not give the same efficiency as a large one on which the coal can burn slower and the air have a better chance to mix with the fuel A strong blast prevents good combustion In the most economical boiler the tubes should be small and long Probably a 15 feet tube, 1½ inch in diameter, is about the best for this class of boiler The power is much reduced as the friction of the gases through the tubes is greater, and in some cases the grate should be smaller so there will be no waste of heat when the work is light

Now we may state the fundamental differences in the designs of the most powerful and the most economical locomotive boilers

It is seen that both must have all the fire box heating surface possible, and as much tube heating surface as can be obtained without interfering with the draft therefore, in actual construction, the only differences of real importance are in the tubes and the size of the fire part of the grate One fundamental design will answer for both by getting as large a fire box and as large a shell as the total weight will permit, and then, perhaps, block off the grate in the most economical boiler, and use the whole of it in the most powerful boiler One must use a large number of small tubes of considerable length in the most economical boiler and in the most powerful boiler use large tubes and shorten them at the back end, as this increases the fire-box heating surface and the draft In both, the fire box and the shell must be as large as possible

These conclusions are founded on theories of combustion that we know all about. No locomotive boiler is too large for economy It is easy to get either the most economical or the most powerful boiler, but to get the design that will give the particular combination of efficiency and capacity that will be the most suitable for a given road is a different matter, and the selection can only be made by trial What we have to start

with is the largest shell with the largest fire box that can be put on the engine, and not exceed the limit of weight, and then the interior must be changed to get the best results

The question of firing the grate has no bearing upon the area of it, but only on the way that the area shall be disposed When the length becomes too great for the fireman to reach the front end of the box the area can be extended sidewise. This has been done with such success that the practicability of it is proved Only those will deny this to be a fact who have not had experience with wide grates If those who have improved the ocean steamers, so that the capacity of the boilers and their efficiency is greater than ever before, even with the forced draft now common, had been so fearful of abnormal dimensions of boilers in cramped places as some railroad men are, we should not now be able to travel across the Atlantic in about five days There seems to be a certain lack of courage to design larger boilers and of firmness and decision in dealing with frills and devices that are wrongly supposed to increase the power of small boilers When there is more originality in thought and more boldness in design we shall hear less about delayed trains on account of lack of steam There are roads that most of us know about on which the schedule time of the most important trains is dependent upon the best efforts of the fireman and whenever there is the least unusual service the superintendent must choose between a double header and a loss of time It may be a severe criticism to say that this is an unnecessary condition, but the truth hurts no one in the end If it be not the truth then the discussion now in progress at the railroad clubs will bring out the fact

As to the theory of combustion that our correspondent enquires about The gases from the fuel and the air coming through the grates, go along in streams and mix imperfectly, and therefore much more than the net amount of air to burn the fuel has to be let in to get reasonably good combustion The net amount of air is about 12 lbs per pound of fuel, while it is common to use, on the most efficient boilers, as much as 24 lbs

The intensity of the heat that is radiated varies with the square of the distance from the fire All other things being equal, the intensity is four times as much at 1 foot as at 2 feet That is—it decreases as the square of the distance from the fire increases If the absorption of the heat in a boiler was dependent solely upon the taking up of the heat that is radiated from the fire, it would be best to put the fire as near the crown sheet as possible, and in some cases this is actually necessary to get the greatest boiler power—as in the case of anthracite coal, for instance The absorption of the heat from the hot gases is an equally important factor as the gases are hotter with some kinds of fuel than with others, and therefore the heating surfaces are differently disposed with respect to the fire In some cases the heating surfaces are close to the fire, and in other cases the surfaces are shielded from the direct heat by brick arches.

One of the limits to the depth of the fire box and to the length of the brick arch is found in the shutting off the radiation of the heat from the fire direct to the crown sheet With soft coal and a deep fire box there is a cloud of smoke and gas over the fire and this cuts off the radiation to the crown sheet Clear air does not absorb heat to any great extent, but gases of the kind that are over soft coal fuels when burning will absorb much of the heat from the fire, and for this reason there is a limit to the thickness of the vapor that should be permitted above the fire when it is desired that a boiler shall have the maximum capacity to generate steam

The desirable action of the brick arch is the heating of the gases as they come from the fuel, also it makes a longer flame way and gives the gas a chance to burn before it is extinguished by the tubes The undesirable action of the arch is that it shields the fire-box from the fire and reduces the amount of the heat that is absorbed by radiation In other words, it makes the gases hotter and necessitates that more heat shall be absorbed

by the tubes in contact with the hot gases If it were not for this fact, the brick arch would give more saving than it does on locomotives.

To make a hot chamber for the gases to burn in, the sides of the fire box have been lined with fire brick, but the result was a very hot smoke box and a loss of efficiency, because the fire box sheets were shielded from the fire and the tubes could not take up the heat.

Perhaps the most important experiment that has been made to show the value of placing the grate not too far from the fire, is the one that was made by the Schenectady Locomotive Works The engine was in hard service and there was not as much steam as was needed to make schedule time The grates were raised one foot and the steaming power was *increased To make sure that there was no mistake, the grates were* again lowered and the power of the boiler was reduced This theory of the action of the deep leg boiler in reducing the power, while it may add to the efficiency of a boiler that is not very hard pushed, is an old one, but there is little accurate data in print to support it

It is well known that deep leg boilers with anthracite and short flame coals, where the fire box must do most of the steam making, are not so powerful as those where the crown is down close to the fire, although the economy when the boiler is not forced may be greater with the deep leg It would not be necessary to consider all these factors of combustion were it not that the most economical boiler is not the most practical The old question of power *versus* efficiency confronts one in selecting a boiler design

*It is well understood that smoke consumers are often coal wasters. Perfect com*bustion always costs more than it comes to, and when power and intensity of heat is the all important matter as in the case of locomotives and heating furnaces, one can only completely stop the smoke by permitting losses in the costs of operation This is true of all kinds of plants where the furnaces must be forced to get power It will be found that when the furnaces are not forced the smoke can be reduced, but not removed without reducing the efficiency and this is the case with heating plants and power stations where the boiler capacity is sufficient to give the necessary steam without forcing. When gross power is of itself the desired end a smoke consumer may be found a detriment but when efficiency is desired at the expense of gross power, a smoke preventer will generally increase the economy of the plant

REPORT ON EUROPEAN LOCOMOTIVE BOILERS.

Reprinted from the "Railroad Gazette" dated 11th January 1895.

The September (1894) Bulletin of the International Railroad Congress Commission contains a report on European locomotive boiler shells, fire boxes, tubes, smoke boxes and stacks, by M Ed Sauvage, one of the principal engineers of the Eastern Railroads of France It is impossible to publish all of this comprehensive and interesting report in these columns, but the gist of it is given in what follows

The report is divided into sections about as follows —

Steel for boiler shells and fire boxes and tests for steel sheets, different forms and sizes of tubes, their effect on the capacity of the boiler and their location in the tube sheet, incrustation and systems of boiler feeding, the effect of the length of tubes and the smoke box arrangements for the production of steam The valuable work done by the late M Henry, Chief of the Mechanical Department of the Paris, Lyons and Mediterranean road, showing the effect of the length of the tubes, the fire brick and water arches and the draught on boiler capacity, is given in a condensed form in this report, and was given more in detail in the "Railroad Gazette," July 4th, 1890 The results have since been published by Dunod and Vicq, Paris, 1894, as an extract from the "Annales des Mines" of August 1894 It will repay those who are interested in the conditions which govern steam production in locomotive boilers to procure the complete work and read it There are a number of plates giving data that are particularly useful to American locomotive designers

M Sauvage's report says that, although in the United States steel boilers and fireboxes are universal, yet in Europe, while steel is frequently used for boiler shells, it is seldom used for fire boxes, and that up to this time the experience with steel fire-boxes in Europe is confined within experimental limits, and they are not yet adopted for general use Accompanying this report are numerous drawings showing boiler construction both with iron and steel shells, and with copper and steel fire boxes In general, the illustrations show the European practice with which all Engineers are more or less familiar One thing which must impress the reader, with regard to these designs, is that *no expense is spared to make the boilers strong and safe, and to hold the sheets so that* there is no motion when the pressure changes

There are given 27 European railroads that are using, or are experimenting with steel boiler shells, and it is said that there are others not mentioned in the list, and that no trouble has been experienced with steel shells except on the Roumanian lines where there have been some cracked sheets These lines have 55 steel boiler shells in use at the present time

In Europe only the softest quality of steel is generally used and recently there has been a general reduction of the tensile strength, and there is an inclination to use still softer material The inspection consists of tensile and elongation tests and physical examination by bending, prior to accepting the sheets Phosphorus is reduced to the lowest practicable limit. In Austria the reduction of area of the test specimens at the

point of rupture is taken in the place of elongation The following table shows some of the more characteristic tests for shell steel used by European railroads —

Table showing the general characteristic tests prescribed for steel sheets for European Locomotive Boiler shells

ROAD	Tensile strength lbs per square inch	Elongation per cent	Contraction of area at point of fracture per cent	REMARKS
Norwegian State	53,000 to 59 000	20 in 8 inches		
North Western of Austria	54 000 to 62 000		52	
Austria Hungary State	50 000		60	
King Ferdinand North	57 000 to 64 000		50	Flange sheets
"	66 000 to 74 000		37	Sheets not flanged
St Gothard	49 000 to 54,000	25 in 8 inches		Flanged sheets tested both cross wise and length wise of rolling
" "	52 000 to 57 000	25 in 8 inches		Sheets not flanged
Jura Simplon	57 000 to 59 000	26-21 in 8 in		
Mediterranean	51 000 to 60 000	30 28 in 8 in.	.	Tested both cross wise and length wise of rolling
Southern Adriatic	53 000 to 59 000	40 25 in 3 in	—	
London Chatham and Dover	56 000 to 67 000	25 in 8 inches		
Lancashire and Yorkshire	59 000 to 67 000	20 in 8 inches		
North London	57 000	26 in 10 in		
Glasgow and South Western	56 000 to 67,000	25 in 8 inches		Tested both cross wise and length wise of rolling
Great Northern of Ireland	Drifting and bending tests only			
North Eastern	59 000 to 67 000	26 in 4 inches		
Natal Government and Great Indian Peninsula	61 000 to 69 000	25 in 6 inches		
Western Railroads of France	64 000 to 72 000	25 in 4 inches		

The trials of steel fire boxes in Europe have not been very successful, and there are now but few in service The most extended experiences are those of the Paris Lyons and Mediterranean and the Great Eastern road in England The conclusions of M Chabal of the Paris, Lyons and Mediterranean, from his study is that if pure soft steel is used fire boxes of that metal are safe They should be carefully made, and sudden cooling should be avoided The employment of steel is but very little more economical than copper, and the principal advantage of the steel box is the decreased weight The report by M Sauvage says that these opinions of M Chabal cannot be taken as representing that of European engineers generally

The report has much information about the various systems of placing tubes in European locomotives and about boiler bracing, smoke stacks and boxes boiler scale,

etc, which cannot be given here, but the whole is summed up in the following conclusion by M Sauvage —

1st The use of soft steel sheets for the shells of locomotive boilers is shown by current practice, and it is justified by the fact that these sheets are more uniform in quality than those of iron

2nd The steel should be very soft, as shown by tensile strength which should not exceed 64 000 pounds per square inch and should lie between 50,000 pounds and 57 000 pounds The plates should come from the best raw materials, and be as free from phosphorus as possible

3rd The use of steel in the place of iron sometimes permits an increase of pressure without increasing the thickness

4th The manipulation of soft steel sheets does not require great precaution because they will stand local heating and bending A desirable precaution is annealing the sheets after having worked them, and before riveting up This is not always necessary where long experience has proved the constant quality of the material, and where the workmen are known to be reliable and accustomed to handling steel

5th Steel fire boxes continue to be almost unused in Europe Some trials have been made which do not indicate that they are much more economical in service than copper, at least not with the qualities of steel obtainable in Europe However with small locomotives having comparatively little work to do steel fire boxes may be very advantageous

6th Tubes of iron or steel are being more and more employed in the place of brass This substitution may be made without inconvenience, and is a great economy

7th It is useless to solder an end section of copper on tubes of iron or steel [*This conclusion is the result of experience with iron and steel tubes that have had an end of copper about 6 inches long put on at the fire box end, probably to increase the life of the flues—Editor*]

8th The iron and steel tubes are rolled or expanded by a mandril in the holes in the tube sheets which are made cylindrical or slightly conical

9th The riveted over part or bead on the ends of the tubes at the tube sheet is not absolutely necessary or indispensable

10th The ferrules for the ends of the tubes should only be used on the fire box end

11th Generally speaking damage to the tubes can best be prevented by care in handling the boilers When the tubes are correctly put in they will give no trouble when the firing is regular, and the entrance of the cold air to the fire box is prevented as much as possible Boilers should be cool before being emptied and especially before washing with cold water It is bad practice to draw the fires before entering stations, as this lets cold air into the fire box and injures the tubes

12th Boiler compounds for reducing scale are useful for preventing hard deposits but the composition must be selected to suit the local conditions and the nature of the water

13th Purification before using feed water that is rich in carbonate of lime, and above all, water containing selenites, is useful, but this plan requires a large outlay for apparatus, yet it often happens that the saving in fuel and boiler repairs and washing gives a great important economy.

14th The introduction of the feed water into the steam space which rapidly removes the air from the water, and prevents local cooling of the plates, is worthy of trial

15th Locomotive tubes are generally not longer than 13 to 16½ feet, and this shows the bearing which the data from the boiler tests, given in the report, have on the boiler capacity of the boiler to generate steam

16th The area of the passage through the tubes ought to be as large as possible, and *this justifies omitting the ferrules inside of the tubes at the ends* The diameter of tubes should not be too small, and they should not be brought too close together The inside diameter should be from 1 6 to 2 in, and the distance between the tube holes in the sheets should not be less than 6 to 7 inch

17th The tubes with wings on the interior, such as those of the serve type for locomotives, have an outside diameter of 2 4 to 2 8 in because tubes *smaller than this are* generally made in too short lengths It is, perhaps, advantageous to substitute tubes with wings for the ordinary tubes of 2 in in diameter, but in that case the number of wings, or the size, should be reduced

18th The relative efficiency of tubes arranged at the corners of a square, that is in vertical and horizontal rows and those arranged at the corners of the square with one tube in the centre of the square that is, in vertical rows, and not in rows horizontally, is about the same Preference is generally given to the arrangement in both vertical and horizontal rows

19th It is not apparent that there is any particular difference in the capacity of boilers to generate steam, no matter what the metal of the tubes may be, that is, whether it is copper, iron, or steel

20th The effect of the volume of the smoke box is scarcely appreciable The long smoke boxes such as are used in America, have been tried in Europe by many railroads, but do not seem to give better results than shorter boxes It seems preferable to use the shorter box

21st It is not apparent that there is any marked superiority with any type of smoke stack The slightly conical form, wider at the top seems to be preferred It is well to prolong the stack into the interior of the smoke box, using a funnel form for the interior The height of the exhaust nozzle ought not to be much more than the upper row

22nd Almost any form of spark arrester is, of course an advantage in reducing sparks but all interfere with the draft more or less without being absolutely spark proof The simple netting suffices in most cases

23rd The annular exhaust nozzle seems to be the best, but it is complicated in design when the exhaust is made variable

24th The exhaust nozzle of single blast pipes should be variable, but it is best that *the variation* does not permit too much reduction in the size of the nozzle No doubt it is on account of permitting too much reduction of the nozzle that the variable exhaust has been sometimes pronounced injurious or useless *The simple design of two movable* wings seems all that is necessary

25th We refer here to the rule indicated in conclusion, No 21, regarding the height of the exhaust nozzle It should not exceed much the top row of tubes, even when the stack is not prolonged into the smoke-box

26th The speed has no apparent influence on the production of steam In other words, the quality of the weight of steam escaping per second with the same terminal pressure in the cylinders is the governing condition The frequency of the blast has no particular effect This is shown by the action of compound locomotives with two cylinders

14th The introduction of the feed-water into the steam space which rapidly removes the air from the water, and prevents local cooling of the plates, is worthy of trial

15th Locomotive tubes are generally not longer than 13 to 16½ feet, and this shows *the bearing which the data from the boiler tests, given in the report, have on the boiler* capacity of the boiler to generate steam.

16th The area of the passage through the tubes ought to be as large as possible, and this justifies omitting the ferrules inside of the tubes at the ends The diameter of tubes should not be too small, and they should not be brought too close together The inside diameter should be from 1·6 to 2 in, and the distance between the tube holes in the sheets should not be less than 6 to ·7 inch

17th The tubes with wings on the interior, such as those *of the serve type for locomotives*, have an outside diameter of 2 4 to 2 8 in because tubes smaller than this are generally made in too short lengths It is, perhaps, advantageous to substitute tubes with wings for the ordinary tubes of 2 in in diameter, but in that case the number of wings, or the size, should be reduced

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THE COUNTERBALANCING OF LOCOMOTIVES.

Reprinted from "Engineering News," dated 10th and 17th January 1895

Leading article

On another page of this issue (see pages 255 to 272) we reprint lengthy extracts from three bulky papers which have recently appeared on the counterbalancing of locomotives Within the past two or three years this subject has been taken up in a more thorough way than ever before, and the three papers which we have abstracted cover pretty well the results of the latest investigations

For the benefit of our readers who have not the time or inclination to go into an extended study of this matter, but who desire to know what the "state of the art" is, we have determined to restate some of the important facts

In the first place, it is true that the great bulk of the locomotives now in service are not so well balanced as they might be There are nearly a score of different empirical rules in use for balancing, and the results obtained by them have varied all the way from very good to very bad The harm which may be done by a badly-balanced locomotive to the track, and to its own machinery, and the serious strains which may be induced in bridges, make the matter of great importance and make it imperative on every railway manager to see to it that any locomotives in the motive power of his road, which are not known to be well balanced, should be measured, calculated, and corrected if need be, at the earliest possible time

We now know that a badly balanced locomotive may kink heavy rails so badly that they will have to be taken up and scrapped We know that its wheels may actually be lifted off the rail at high speeds and evidence that derailments have occurred from this cause has been presented Such bad balancing occurs through the use of incorrect rules or errors in applying them, through placing too much counterweight in the trailing wheels on account of the difficulty of getting the proper amount in the main driver, through the loss of lead from lead filled counterweights, and through running dead engines or engines with their rods down at ordinary speeds

Turning now to the practical question how a locomotive should be counterbalanced we know that in the first place all the revolving weight should be balanced The formulas worked out by Mr R A Parke, M E, of the Westinghouse Air-Brake & Co and presented by him in a paper read before the New York Railroad Club a year ago, still stand as the only correct rules for balancing which have ever been worked out Mr Parke's formulas were published in our issue of March 1st, 1894, but since that time he has discovered an error in the algebraic work, by which the formulas were deduced which corrected leaves the formulas, or rules, in the form given below.

Counterbalancing of Locomotives

The process of finding the proper weight of counterbalance for locomotive driving wheels naturally divides itself into four parts —

1 The wheel itself including the crank and crank pin must be balanced by a certain weight of counterpoise

2 The weight of the parallel rod or rods which the crank pin carries requires a certain additional weight in the counterpoise

3 The counterpoise of the main driving wheel should have a certain additional weight to balance the vertical influence of the main rod and reciprocating parts upon the crank pin

4 A certain additional weight should be equally distributed among the counterpoise of the several wheels to secure partial horizontal balancing of the main rod and reciprocating parts

The calculation of the counterbalance weight necessary to balance the wheel itself is a simple matter of computing weights and leverages, similar to the balancing of any other body rotating about its axis, and need not be explained here The additional weight in each wheel needed to balance the parallel rod is calculated in a similar way, the weight of the parallel rod which is carried by the wheel being supposed to be concentrated at the centre of the crank pin

For finding the additional weight which should be added to the main driver to balance the vertical influence of the main rod and reciprocating parts, Mr Parke gives the following rule

The weight of additional counterbalance in main driver required to balance the vertical influence of the connecting rod and reciprocating parts multiplied by the distance of its centre of gravity from the centre of the wheel, equals the weight of the connecting rod multiplied by the quantity:

$$r\,\frac{\frac{1}{2}l^2-\frac{1}{4}r^2}{l^2-r^2}$$

plus the weight of the piston piston rod and cross head multiplied by the quantity—

$$r\,\frac{r^2}{l^2-r^2};$$

In these equations r= the distance from the centre of the driving wheel to the centre of the crank pin, and l=the length of the connecting rod between centres

A locomotive with counterbalances applied according to the above rules will be in perfect vertical balance at all speeds That is, there will be no increase of pressure on the rail when the counterbalance weights are down, and no tendency of the wheel to lift from the rail when the counterbalances are up

It is now necessary to add something to the counterbalance weights to balance the horizontal effect of the reciprocating parts What percentage of their weight should be balanced is a matter which we discuss below, but whatever the percentage may be, the rule developed by Mr Parke is as follows —

Let the weight of additional counterbalance required to balance the horizontal effect of a given percentage (=m) of the weight of the reciprocating parts=W_4

Then $W_4 \times$ distance from its centre of gravity to the centre of the axle$=\frac{mr}{l^2-r^2}$ multiplied by the quantity weight of connecting rod $\times(\frac{1}{2}l^2-\frac{3}{4}r^2)+$ weight of piston piston rod and cross head (l^2-2r^2) The quantities r and l have the same value as abov

It must be understood that all the weight thus added to balance the horizontal effect of the reciprocating parts acts vertically as an unbalanced weight and provided the re-

volving parts are correctly balanced according to the rules above stated, it is this additional counterbalance, and this alone, which produces the hammer blow on the rail It is manifest, therefore, that although, so far as balancing the horizontal effect is concerned, it makes no difference how this additional counterweight is distributed among the drivers, to make the hammer blow at a given point on the rail as small as possible, this additional counterweight should be divided equally among all the drivers

What percentage of the weight of reciprocating parts should be balanced will depend upon the class of engine, the speed at which it is to run, and other considerations The Southern and South Western Railway Club Committee, whose report we shall give next week recommends that modern heavy, well designed locomotives, with comparatively light reciprocating parts should have 50 per cent of the weight of these parts balanced, that lighter engines, less able to withstand strains and absorb the inertia of the reciprocating parts, should have 66 per cent of the weight balanced, and that compound engines, with very heavy reciprocating parts, should have 75 per cent of the weight balanced

It will be seen that this committee represent the motive power side of the case, and have gone on the principle that the engine must ride steadily any way, and the track must take the rest as hammer blow Probably a committee of track supervisors and bridge superintendents would tend to the opinion that the locomotive with the heaviest reciprocating parts should have at most no more counterbalance than the engines with lighter pistons and cross heads It must be conceded however, that managing officers will invariably insist that trains must be hauled without jerking, whatever happens to the track

Computations and practical experience show that common types of locomotives, running at ordinary speeds and balanced according to the above rules, will ride well and will not produce an excessive hammer blow upon the rail But locomotives with excessively heavy reciprocating parts, or those which have exceptionally heavy wheel loads, or those which are run at very high speeds, ought, at least to have their hammer blow calculated, to ascertain whether it is in excess of the safe limit

Perhaps the most important and obvious moral that is taught by the recent investigations is that the weight of reciprocating parts ought to be reduced If in the above formula for balancing the reciprocating parts, we suppose the length of the connecting rod to be eight times the length of the crank radius, we find that the vertical effect of a counterbalance weight sufficient for full horizontal balance will be the same as if the weight of the piston piston rod and cross head, and half the weight of the connecting rod were concentrated at the crank pin We may also note that at a speed of 60 miles an hour, which almost any locomotive in fast passenger service may attain over short distances with a 6 ft driver and 24 in stroke, every pound of weight in the reciprocating parts that is counterbalanced produces 26 lbs of hammer blow upon the rail, and every pound of weight in the connecting rod produces 13 lbs. of hammer blow upon the rail

Remembering that the hammer blow increases as the square of the speed, it is evident that locomotives designed for fast service should have their reciprocating parts made as light as possible, and that it will pay well to do it Already a number of railways have begun the use of cast steel pistons and are modifying their designs with a view to saving weight There is still large room for improvement, however, and we shall probably see pistons and cross heads forged of nickel steel With such a material in the hands of an intelligent designer, there is no reason why the weight of reciprocating parts should not be brought down to half, or even a third, of the weights now common

We may appropriately refer in this connection to the popular belief, which appears to be specially prevalent among electrical engineers that the "hammer blow" is a serious and irremediable drawback to the steam locomotive While a badly balanced locomotive may do serious damage, the investigations which have been carried out show that with counterbalances correctly applied, and the reciprocating parts reduced in weight, as they easily may be, a steam locomotive can run up to any speed thus far recorded without producing an excessive hammer blow or causing vibration of the train.

The current talk concerning hammer blow has also had the effect of encouraging a number of inventors to work out designs of "balanced" locomotives, by which is meant one so devised that reciprocating parts of the same weight are given equal motion in opposite directions at the same time If they can design such a locomotive without increasing its cost over that of the present type of engine or making it more complicated or less satisfactory in any way, they may have some chances of success but it should be plainly understood that a few dollars expense in a better material for reciprocating parts, with intelligent design of these parts and proportioning of the counterbalance weights will make the present locomotive practically unobjectionable in this respect

A most important subject, in regard to the efficient performance of locomotives, which is now being extensively investigated by mechanical engineers, is that of the proper counterbalancing of the reciprocating and revolving weights of the wheels and driving mechanism, so as to ensure ease and steadiness in riding and to prevent uneven and severe strains upon the rails A large part of the investigation has been devoted to the proper counterbalancing of engines built in accordance with existing plans, but a no less important part is that which has reference to reducing the weights of the reciprocating parts so as to reduce the amount of counterbalance weight required There is but little approach to uniformity in this respect, and, as noted below, nearly twenty different rules are in extensive use, and are all claimed to be satisfactory by those who use them Even this is not the limit, for carelessness and error in applying the rules variations imposed by peculiarities in the designs of engines and alterations made subsequently (intelligently or otherwise) lead to the greatest possible variation from any attempt at uniformity Two papers on this subject have been given in ' Engineering News of April 26 1890, and February 22 1894 In the present article we give abstracts of three recent papers on this subject, the first two of which were presented at the December Meeting of the American Society of Mechanical Engineers and the third at the November Meeting of the Southern and South Western Railway Club

First Paper

The first paper was one on " Rail Pressures of Locomotive Driving Wheels,' by Mr D L Barnes of Chicago, which opened by a discussion concerning the effect of equalising levers in distributing the weights on the several wheels The author considers that equalisers are not really necessary where the track is smooth and level and that they have little effect on the weights per wheel at high speeds since the velocity of the wheels over the track at high speeds is so great that there is not time for the wheels to drop down into a depression or to follow down the depression of a weak joint or unsupported section of a rail We are inclined to doubt, however, whether any extent of track is so perfect as to make the use of equalisers inadvisable and as practically every locomotive has to travel during its service over various qualities of track and at various speeds, it does not seem advisable to consider the omission of the equalising system nor is it probable that it will be considered by practical men in this country The following are extracts from Mr Barnes' paper —

As a locomotive goes along a track the driving wheels rise and fall according to two conditions 1, the depth of the depressions and rises, 2 the speed The faster the speed

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As a locomotive goes along a track the driving wheels rise and fall according to two conditions 1, the depth of the depressions and rises, 2, the speed The faster the speed

the less will be the rise and fall, unless the wheel gets into a vertical oscillation owing to regularity in succession of the depressions and rises. Vertical oscillations because of such regularity probably seldom occur. To mount over a rise increases the pressure on the track in the same way as when the driver is rising out of a depression. From this it is clear that the weight on the driving wheels at high speeds is a variable quantity, depending little on the equalisers, and mainly on the speed, stiffness of springs, inertia of the mass of the wheels and greatly upon the weight of the reciprocating parts.

Rail pressures for the main drivers are affected by the angularity of the connecting rods. For locomotives running ahead the rail pressures are increased by the push and pull of the connecting rods, but for locomotives running backward the rail pressures are decreased by the same action. It is evident that the weight of locomotive drivers on the rails, as measured by track scales, is only the normal weight and is but little indicator of the maximum rail pressures.

In the counterbalancing of locomotives it has been found that from one third to one-half of the weight of the reciprocating parts need not be balanced, although on some railways it is customary to balance all reciprocating weights. The roughness of locomotive service permits a decrease of the balance for reciprocating parts of at least one third without causing disagreeable longitudinal oscillations and lateral motions of the engine. Some interesting information about this matter has been presented to this Society by Professor Gaetano Lanza (Trans. Am. Soc. M. E. Vol. X, page 302). The balancing of the revolving weights should be complete, and this is done in the ordinary way of balancing flywheels.

One fact that has been determined by practical experience is that so far as the locomotive itself is concerned the balancing is practically perfect when the balances are placed in the wheels opposite the crank pins, and when all of the *revolving parts* are balanced and not more than a 100lbs. of reciprocating parts for light engines and 200lbs. for heavy engines are left unbalanced. When scientifically analysed this method of balancing is found to be imperfect, and such analysis shows that the balancing would be more exact if the counterweights were placed not quite opposite the cranks, and if an additional balance to counteract the effect of the balances on the opposite side was placed in each wheel at right angles with the crank, but in practice such a plan prevents the duplication of the wheels and gives no better results than the simpler plan commonly followed, that is if the reciprocating parts be not unnecessarily heavy. The *effect of putting in the additional counterweight* is to increase the maximum rail pressure, which is too great under the simpler plan of counterbalancing and therefore, the additional balance would better not be used unless for locomotives already constructed, where the fundamental design is bad *and such balance* is added for correction of existing evils.

The practical problem of balancing is not one of "how to balance," but of reducing the total weight of the reciprocating parts to a minimum. What can be done in the way to improve locomotives is *indicated by what has* been done in decreasing the weight of pistons, cross heads and main rods. These parts on American locomotives are generally heavier than are necessary for the service, and a reduction of one half in weight is possible in many cases. The average possible reduction may be taken as 40 per cent. for all designs. It is *only within the* short time since high maximum speeds have become common practice that the effect of heavy reciprocating parts has been such as to call attention to the need for reductions in weights. Now bent rails and damaged track reports are too common to permit further neglect of a proper consideration of the weights of reciprocating parts.

No doubt heavy locomotives injure the track more than lighter ones because of the greater weight, but it is by no *means* certain that the heaviest consolidation engines, or

engines having great weight per wheel, when run at moderate speeds, injure the track as much as the lighter locomotives when run at high speeds, yet if the heavier locomotives were run at the same high speeds with equal weight of "excess balance," the effect would, of course, be worse The point of this is, that when track is damaged, particularly at the foot of grades, the cause may not always be found with the heavier locomotives having the greatest weight per wheel, but is more likely to be found with those engines having small wheels and heavy reciprocating parts where the number of revolutions per minute is high, although the speed may be moderate

An important example of damaged track caused by light engines is one that occurred in 1893 on a line where there are engines with weights per wheel varying from 13 000 to 18,000 lbs, the types being eight wheel, ten-wheel, and consolidation. The damage was caused by the lightest type of engine running at an excessive speed on a down grade In another case a light eight wheel engine was run without rods in a freight train at 50 miles an hour, and the result was two miles of badly damaged track and two broken bridge rods. In another case a consolidation engine was broken down on one side and the rods were taken off on that side and the engine was run faster than schedule speed to make up time The effect was several miles of bent rails The bends are seldom noticeable unless they are as much as one eighth inch Occasionally the bends are as much as one inch vertically and half an inch horizontally inwards toward the centre of the track, the horizontal bending being undoubtedly due to the fact that the rail is supported on the bottom flange and the load is applied on top, and generally nearer the inner than the outer edge *

Contrary to what one might suppose from the extent of the discussion, there is nothing to prevent a practically perfect counterbalancing Theoretically, it is not possible to exactly counterbalance the reciprocating parts of a locomotive with a balance revolving in the wheel, but practically the weight of the locomotive is so great in proportion to the forces remaining unbalanced that the engine is not more shaken than can be permitted To keep a locomotive in perfect balance the centre of gravity of the whole machine must remain in the same position longitudinally and vertically at all times, but this can only be when the parts are moving in such a way as not to disturb the centre of gravity If one part moves ahead, another part of equal weight must move back an equal distance with the same velocity at all times that is, when the two parts start from the same point But if the parts start from different points the weights or the velocities must be different, that is to say, the parts must always so move that the centre of gravity is unchanged If the reciprocating parts are heavy and the engine is light, the unbalanced forces may be greater than can be permitted, but as engines are now built and balanced, the result is practically perfect so far as the locomotive is concerned

The effect on the track depends little upon the method adopted for counterbalancing and is almost wholly fixed by the weight of the reciprocating parts In any given locomotive there can be unbalanced forces without shaking the engine too much, and the amount of the unbalanced force that can be permitted depends upon the gr[illegible] weight, and, also, somewhat upon the length of the engine The longitudinal shaking called "plunging" is not affected by the length of the engine but the lateral shaking called "nosing" is generally less with long engines than with short ones as the inertia of the locomotive and the moment of the resistance of the friction of the driv[illegible] lateral slipping are greater

If the cranks on opposite sides of the engine could be placed at the same that is, both ahead or back at the same time, there would be no tendency to [illegible] the forces that produce it would balance When the cranks are at 90 deg the [illegible]

* Some cases of such bending of rails were noted by correspondents in our issue of [illegible] March 22nd 1894.

tendency to "nosing" occurs at the different points of revolution on the two sides. This is true of the steam valve inertia as well as the inertia of the reciprocating parts When the cranks are at 180 deg the resultant force which produces "nosing" is in the main doubled and so far as "nosing" is concerned, it is easier to balance locomotives having two cranks when the cranks are at 90 deg than when at 180 deg

Owing to the fact that the counterbalances in locomotive drivers are not in the same plane vertically as the crank pins and rods which they balance, there is a resultant turning force, tending to turn the locomotive laterally or cause "nosing"

Perfection of counterbalance of reciprocating parts is not only unnecessary, but quite undesirable, as it increases the effect of the counterbalances on the track The part of the counterbalance which affects the track is not that part which is used for the revolving weight, as that is balanced in all positions by the revolving parts It is the part that is used for the reciprocating parts, and known as the "excess balance," that injures the track, as its centrifugal force is counteracted only horizontally Vertically this part of the counterbalance is free to lift the wheel from the track or increase the pressure on the rail, and this is the only reason why it is very desirable to use as little counterbalance for the reciprocating parts as possible. If all counterbalance for reciprocating parts is omitted the effect is to cause ' plunging ' and "nosing ' With a given weight of unbalanced reciprocating parts and a given speed, the lighter the engine the greater will be the oscillation, both in ' nosing' and "plunging ' The heavier the locomotive, the less will be the percentage of reciprocating weight that needs to be counterbalanced. The limit of the counterbalance that must be used for reciprocating parts is found when the oscillations are not too disagreeable for the engineman and fireman, and for the mail clerks in the postal cars, which are usually run at the head of the train The "plunging" oscillations are the only ones that effect the cars and these, even in rather extreme cases, do not extend further than the third or fourth car from the engine

The effect of the 'excess balance" is peculiar, and has been studied by mathematical analysis in a limited way and by chalking the track and running a locomotive over at high speed In such cases it has been found that the drivers lifted from the track The distances between the depressions of the rails correspond nearly with the circumference of the driving wheels The same effect is produced to a greater extent when locomotives are hauled over the road at fast freight speed with the rods removed In such cases nearly all of the counterbalance weight becomes an "excess," and is to be treated just as an ' excess balance for reciprocating parts Damage to the track from this origin has caused orders to be issued on some roads that locomotives without rods shall not be hauled at a speed exceeding 20 miles an hour Professor Goss, at Purdue University, has shown very clearly that locomotive drivers lift from the track at high speed

It was proposed by the Master Mechanics' Association in 1886 (Proceedings, page 156) that an apparatus be constructed for measuring the effect of the "excess balance," and drawings were made, but the machine was not built. The inefficiency of any such apparatus appears from the fact that when strong enough to withstand the shock, its weight would be so great that its inertia would destroy the accuracy of the record In dynamometer car work, the car is placed next to the locomotive, and the oscillation longitudinally due to the unbalanced portion of the reciprocating parts, even on what are considered to be well balanced engines is] distinctly visible on the diagram The effect of the oscillations is to cause a variation of the recording pencil which corresponds with the revolutions of the drivers This small oscillation is neither disagreeable to the engineman and fireman nor detrimental to the locomotive To get perfection of counterbalance locomotives have been hung up on chains clear of the track, and have been run at high speed A pencil attached to the front of the engine

describes an ellipse in a horizontal plane with an axis inclined to the centre of the locomotive It is possible to add sufficient balance, and so locate it as to reduce the amplitude of the vibrations in a horizontal plane to a very small amount, but such perfection is not necessary in practice, and is not desirable, as it requires more "excess balance," and the bad effect on the track is increased

While it is true that a counterbalance travels, with respect to the surface of the earth, in a path that resembles a cycloid and is, in fact, a trochoid, yet with respect to the engine, the counterbalance travels primarily in a circle, and only varies from that path with respect to the engine when the rail deflects or the driver lifts from the rail. It seems hardly necessary to say, that in making calculations about the effect of the counterbalance, either on the track or on the locomotive, the trochoidal path with respect to the surface of the earth need not be taken into account

The centrifugal force of the counterbalances acts practically over the rail line, but the centrifugal force of the revolving parts, and the inertia of the reciprocating parts, act outside of the rail line The resultant of these forces tends to revolve the engine, first in one direction, and then in the other, and thus cause "nosing '

In regard to variations in rail pressure due to vertical oscillation of the driving wheels, Professor Lanza, in 1886, after a brief consideration of a specific problem, submitted to him by the writer, give the opinion that the maximum and minimum rail pressures did not occur at the upper and lower positions of the counterbalance The first useful information for a solution of the problem was gathered in 1891 by the late Professor Arthur T. Woods, who made an experiment with a model under assumed conditions, the results of which showed that under those conditions the maximum and minimum rail pressures did not take place when the counterbalance was directly up or down These results were given first in the "Technograph," 1891, and afterwards in the "Railroad Gazette," August 14, 1891, page 560 In 1893 Professor W F M Goss, of Purdue University consented to determine from his test locomotive some fundamental facts about the revolution of a locomotive driver, and he devised the plan of putting an iron wire between the driver and the carrying wheels to learn where the driver left the rail and where the pressure was greatest The results showed that the maximum lift and maximum pressure did not occur when the counterbalance was directly up or down, and, further, that succeeding revolutions did not give duplicate results This last Professor Goss attributed to the fact that the engine rolled sidewise on the driving springs, and so varied the pressure on the rail

The effect of the "excess balance" on tire wear must be considerable when the revolutions per minute are as great as they are with large drivers at very high speeds and small drivers at moderate speeds It has been shown, both mathematically and by the results of the practical experiments at Purdue that with drivers of ordinary diameter the tires are off the track for a considerable portion of a revolution at 60 miles an hour, when the "excess balance" is about the ordinary amount. Omitting the wear of brakeshoes, which ordinarily do not wear the tire where it bears upon the rail, it is evident that if the average locomotive should be continuously run at 70 miles an hour there would be one point on the tires, except the main tire that would never touch the rail and would therefore never be worn The main wheels do not lift as much as the back wheels, that is, when running ahead, for the reason that the obliquity of the main rods causes a downward pressure on the track, which counteracts somewhat the lifting tendency

In looking for the causes of flat spots on driving tires of fast moving locomotives, the first point of importance is to find the part of the revolution where there is the least wear. This point will generally be found following the crank, that is, at a point where the tire

tendency to "nosing" occurs at the different points of revolution on the two sides This is true of the steam valve inertia as well as the inertia of the reciprocating parts When the cranks are at 180 deg the resultant force which produces 'nosing' is in the main doubled, and so far as 'nosing' is concerned it is easier to balance locomotives having two cranks when the cranks are at 90 deg than when at 180 deg

Owing to the fact that the counterbalances in locomotive drivers are not in the same plane vertically as the crank pins and rods which they balance, there is a resultant turning force, tending to turn the locomotive laterally or cause "nosing"

Perfection of counterbalance of reciprocating parts is not only unnecessary, but quite undesirable, as it increases the effect of the counterbalances on the track The part of the counterbalance which affects the track is not that part which is used for the revolving weight, as that is balanced in all positions by the revolving parts It is the part that is used for the reciprocating parts and known as the "excess balance,' that injures the track, as its centrifugal force is counteracted only horizontally Vertically this part of the counterbalance is free to lift the wheel from the track or increase the pressure on the rail, and this is the only reason why it is very desirable to use as little counterbalance for the reciprocating parts as possible If all counterbalance for reciprocating parts is omitted the effect is to cause plunging and nosing ' With a given weight of unbalanced reciprocating parts and a given speed, the lighter the engine the greater will be the oscillation, both in 'nosing' and "plunging" The heavier the locomotive, the less will be the percentage of reciprocating weight that needs to be counterbalanced The limit of the counterbalance that must be used for reciprocating parts is found when the oscillations are not too disagreeable for the engineman and fireman, and for the mail clerks in the postal cars, which are usually run at the head of the train The "plunging' oscillations are the only ones that effect the cars and these, even in rather extreme cases, do not extend further than the third or fourth car from the engine

The effect of the "excess balance" is peculiar, and has been studied by mathematical analysis in a limited way and by chalking the track and running a locomotive over at high speed In such cases it has been found that the drivers lifted from the track The distances between the depressions of the rails correspond nearly with the circumference of the driving wheels The same effect is produced to a greater extent when locomotives are hauled over the road at fast freight speed with the rods removed In such cases nearly all of the counterbalance weight becomes an 'excess and is to be treated just as an excess balance for reciprocating parts Damage to the track from this origin has caused orders to be issued on some roads that locomotives without rods shall not be hauled at a speed exceeding 20 miles an hour Professor Goss, at Purdue University has shown very clearly that locomotive drivers lift from the track at high speed

It was proposed by the Master Mechanics Association in 1886 (Proceedings page 156) that an apparatus be constructed for measuring the effect of the "excess balance," and drawings were made, but the machine was not built The inefficiency of any such apparatus appears from the fact that when strong enough to withstand the shock, its weight would be so great that its inertia would destroy the accuracy of the record In dynamometer car work, the car is placed next to the locomotive, and the oscillation longitudinally due to the unbalanced portion of the reciprocating parts, even on what are considered to be well balanced engines is distinctly visible on the diagram The effect of the oscillations is to cause a variation of the recording pencil which corresponds with the revolutions of the drivers This small oscillation is neither disagreeable to the engineman and fireman nor detrimental to the locomotive To get perfection of counterbalance locomotives have been hung up on chains clear of the track, and have been run at high speed A pencil attached to the front of the engine

describes an ellipse in a horizontal plane with an axis inclined to the centre of the locomotive It is possible to add sufficient balance, and so locate it as to reduce the amplitude of the vibrations in a horizontal plane to a very small amount, but such perfection is not necessary in practice, and is not desirable, as it requires more 'excess balance,' and the bad effect on the track is increased

While it is true that a counterbalance travels, with respect to the surface of the earth, in a path that resembles a cycloid and is in fact, a trochoid yet with respect to the engine, the counterbalance travels primarily in a circle, and only varies from that path with respect to the engine when the rail deflects or the driver lifts from the rail. It seems hardly necessary to say, that in making calculations about the effect of the counterbalance, either on the track or on the locomotive, the trochoidal path with respect to the surface of the earth need not be taken into account

The centrifugal force of the counterbalances acts practically over the rail line, but the centrifugal force of the revolving parts, and the inertia of the reciprocating parts, act outside of the rail line The resultant of these forces tends to revolve the engine first in one direction, and then in the other, and thus cause "nosing"

In regard to variations in rail pressure due to vertical oscillation of the driving wheels, Professor Lanza in 1886, after a brief consideration of a specific problem, submitted to him by the writer, gave the opinion that the maximum and minimum rail pressures did not occur at the upper and lower positions of the counterbalance The first useful information for a solution of the problem was gathered in 1891 by the late Professor Arthur T. Woods, who made an experiment with a model under assumed conditions the results of which showed that under those conditions the maximum and minimum rail pressures did not take place when the counterbalance was directly up or down These results were given first in the "Technograph," 1891, and afterwards in the "Railroad Gazette," August 14 1891, page 560 In 1893 Professor W F M Goss, of Purdue University consented to determine from his test locomotive some fundamental facts about the revolution of a locomotive driver and he devised the plan of putting an iron wire between the driver and the carrying wheels to learn where the driver left the rail and where the pressure was greatest The results showed that the maximum lift and maximum pressure did not occur when the counterbalance was directly up or down and, further, that succeeding revolutions did not give duplicate results This last Professor Goss attributed to the fact that the engine rolled sidewise on the driving springs, and so varied the pressure on the rail

The effect of the "excess balance" on tire wear must be considerable when the revolutions per minute are as great as they are with large drivers at very high speeds and small drivers at moderate speeds It has been shown, both mathematically and by the results of the practical experiments at Purdue that with drivers of ordinary diameter the tires are off the track for a considerable portion of a revolution at 60 miles an hour when the "excess balance" is about the ordinary amount Omitting the wear of brakeshoes, which ordinarily do not wear the tire where it bears upon the rail, it is evident that if the average locomotive should be continuously run at 70 miles an hour there would be one point on the tires except the main tire that would never touch the rail and would therefore never be worn The main wheels do not lift as much as the back wheels that is, when running ahead, for the reason that the obliquity of the main rods causes a downward pressure on the track, which counteracts somewhat the lifting tendency

In looking for the causes of flat spots on driving tires of fast moving locomotives the first point of importance is to find the part of the revolution where there is the least wear This point will generally be found following the crank, that is, at a point where the tire

touches the rail when the crank has passed the 90 degree point or lower quarter, the engine running ahead, that being the place where the driving wheel will probably most frequently have the maximum lift. An examination of worn tires of high-speed locomotives shows this to be the case. There are causes of tire wear other than the abrasion due to rolling contact, the principal cause being the slipping of the tires in starting up a heavy train. The 'imperceptible slip' which has been said to exist has never been proved to take place after the engine has reached an ordinary speed, say, of 10 miles an hour, but it occurs sometimes at slow speeds when the engineer is quite expert in handling the throttle. It can be seen when a heavy train is being started and the locomotive is moving at less than 5 miles an hour. It is due to the non uniformity of the moment of rotation produced by the steam pressure on the pistons. The maximum moment when the slipping occurs is slightly greater than the adhesion of the drivers, and for a few degrees of revolution the drivers slip slightly. However, locomotives are not generally run in this way, for the reason that when the balance between the moment of rotation and the moment of adhesion is so delicate the change in the co efficient of friction, caused by a slippery place on the rail permits the engine to slip violently. For various reasons enginemen are required to avoid this. Instructions are generally given to slip the drivers as little as possible. The writer made experiments in 1891 on a heavy grade 17 miles long, of about 117 feet per mile, on the Baltimore and Ohio R R ("Railroad Gazette November 27th, 1891, page 832) to determine whether, under the extreme conditions of hauling a heavy load, there was any slip after starting. The results showed that the drivers made the same number of revolutions when going up the hill with a heavy train as when coming down without load.

Tires wear both by pulverisation of the steel due to rolling contact and by abrasion, and, as the points of maximum wear of each kind do not always coincide, it is difficult to predict where the most worn places will occur, unless all the conditions of speed and service are accurately known. The maximum rail pressures occur with greater uniformity *for back drivers than for main drivers, for the reason that the vertical component of the* piston pressure due to the angularity of the connecting rod varies with different cut-offs and modifies greatly the points of maximum rail pressures. It is only in cases where locomotives are run quite uniformly in speed and piston pressure that it is of any practical use to examine the relation of the positions of points of maximum rail pressure and the points of maximum wear.

Conclusions may be presented as follows —

1. The present method of counterbalancing locomotives by providing in each driver a balance sufficient to fully counterbalance all the revolving parts and an additional balance known as the "excess balance" which has a centrifugal force equal to about two thirds of the maximum inertia of the reciprocating parts, is practically perfect so far as the locomotive itself is concerned.

2 The "excess balance" now generally used for the reciprocating parts and counteracting about two thirds of the maximum inertia of those parts, is too great for speeds above 65 miles an hour with drivers less than 6 feet in diameter, as the track is liable to be damaged by the excessive rail pressure that it causes.

3 The only practical way in which the "excess balance" can be reduced is by reducing the weight of the reciprocating parts, and as these parts are generally made heavier than the service demands, it is possible to reduce the "excess balance" to a point where the rail pressure will not be destructive, provided that the diameter of the drivers be made suitable for the speed.

4 The larger the driver for the same speed and weight of reciprocating parts the less will be the maximum rail pressure caused by the "excess balance"

5 The heavier the locomotive the greater is the amount in pounds of the reciprocating parts that can remain unbalanced without causing the locomotive to shake, in "nosing" and "plunging" more than can be permitted It is not the percentage of the total weight of the reciprocating parts that should be considered in selecting the "excess balance," it is the actual weight in pounds that can remain unbalanced without shaking the engine too much If one third of the weight of reciprocating parts weighing 600 lbs can remain unbalanced, then, if those parts be reduced to weigh but 400 lbs, one half can remain unbalanced and "excess balance" will be needed for but 200 lbs instead of 400 lbs of reciprocating weight

6 The maximum rail pressure of a driving wheel is not at all indicated by the static load of the wheel on the rail The impressed load due to the "excess balance is often double the static load, and the pressure at the point of impact when the wheel lifts from the rail and drops is even greater There appears to be no way of determining what the impact pressure is, but the impressed load due to the "excess balance ' can be calculated by the formula for the centrifugal force About all that is known about the impact pressure is that it is enough at times to bend a 70 lbs rail downward vertically one inch in cases where the engine has small wheels and is run too fast, or has the rods taken off and is run at moderately high speeds or has improper counterbalances

7 The speed at which any given driver will begin to lift from the rail is probably less than that at which the centrifugal force of the counterbalance equals the pressure of the wheel upon the rail, as at speeds lower than that the wheel has small vertical oscillations that may carry it off the rail But the lift will not be important until the speed has increased to a point where the centrifugal force of the "excess balance' is somewhat greater than the pressure of the wheel on the rail

8 The exact height of lift of a wheel in any given case is dependent upon so many unknown and variable quantities in practice, such as the flexibility of the track and the rhythm with which points of equal flexibility succeed each other in the direction in which the locomotive is running that it is impossible to predict what it will be But it is sufficient to know that for the good of the track, and to prevent broken and bent rails, and for the safety of the train following a locomotive, it is not prudent to run a driving wheel at a speed where the centrifugal force of the "excess balance exceeds the pressure of the wheel upon the rail

9 All driving wheels for fast locomotives should be as large in diameter as it is possible to make them, and not decrease the power too much in starting trains

10 The path of the centre of gravity of a wheel, with respect to the engine during a revolution, is an oval figure with the long axis more nearly vertical than horizontal, the inclination of the axis varying constantly owing to the difference in the elasticity of the track at different points, and to other causes

11 The heavier the driving wheel and the parts under the driving springs, and the stiffer the driving springs, the less will be the lift from the rail, all other conditions being equal

Second Paper

The second paper was by Professor W F M Goss, on "An Experimental Study of the Effect of the Counterbalance in Locomotive Driving Wheels upon the pressure between Wheel and Rail,' the experiments being made with the eight-wheel locomotive in the

engineering department of Purdue University, which plant was described in "Engineering News" of May 19, 1892 This plant was burned in January, 1894 but has since been rebuilt on a more complete scale. The special feature of interest in these tests was the method adopted for recording the pressures by means of the degree of compression of a soft iron wire passed between the driving wheels and the supporting wheels representing the rail It was shown that, under certain conditions, the driving wheel actually lifted from its support We quote from the paper as follows —

The apparatus employed consisted chiefly of the Purdue locomotive "Schenectady," which, as is generally known, is mounted with its drivers resting upon wheels of approximately the same diameter with the drivers When the drivers are turned by the engine, the supporting wheels roll in contact with them, the engine as a whole remaining stationary To guide the wire which was to be fed under the driver, a length of three-eighths of an inch gas pipe was secured to the laboratory floor in front of each driver included in the experiment Three pipes were thus arranged A deflector plate was fixed behind the main driver, to turn the wire delivered from this wheel away from the rear driver, but, except for this plate, no attempt was made to control the course of the wire after it left the wheel The wire was of common annealed iron about 0 037 in diameter, carefully straightened, and cut into lengths of 20 feet, that is about 3 5 feet longer than the circumference of the drivers and 2 inches longer than the guide pipe in which the lengths were to be fed to the wheels Wires thus prepared were laid in light wooden troughs to preserve them from injury and a trough thus supplied was placed in line with each guide pipe In conducting the experiments, an operator at each pipe drew a wire from the trough and passed it into the pipe until only about 2 inches of the length remained outside From the relative length of guide tube and wire it was known that the opposite end of the latter was now close to the driver. When desired conditions of speed had been secured and a signal given, a touch of the operator's finger upon the end of the wire was sufficient to start the opposite end under the wheel The starting of the wire was accomplished without commotion, the man in charge being conscious only of having touched it The initial end of each wire was in plan, of the outline shown by Fig 1, Plate LVIII, from which it would appear that when the wire came under the influence of the wheels' motion, the tensional stress upon sections near the end as at A exceeded the elastic limit of the material, this stress being required to impart motion to the mass of wire to the right of A The weight of the 20 ft length was about 1 oz and the time occupied in its passage was usually 1 5 second These facts will help to show the significance of the speeds used in the experiments

The speed of the locomotive was noted from a registering counter, and also by a Boyer speed recorder a permanent record being obtained from the latter instrument To assist in connecting the effect produced on the wire with definite phases of the wheels' motion, a nick was made with a sharp chisel across the face of each driver, in line with the counterweight, as at A, Plate LVIII An impression of this nick was sharply defined upon every wire that passed under it The initial end of the wire could as has been already stated, be determined by an examination, but to leave no doubt as to this matter, and for the purpose of giving a second reference point, one of the wheels was marked with two parallel lines 90 deg from the first reference line, as at C, Fig 2

It was found by a comparison of reference marks that distances along the length of the wires could be taken as representing equal distances around the face of the wheel. Thus, the length of each wire being greater than the circumference of the wheel, it would sometimes happen that a single wire would receive two impressions from the reference mark, the distance between the two points thus impressed upon the wire was found to be equal to the circumference of the wheel This fact made it easy to connect effects left upon a wire with the wheel positions (crank angles) producing them

Counterbalancing of Locomotives

Many of the wires that have been produced by the experiment described have since been carefully calipered at 5 in intervals, the results plotted, and a smooth curve drawn through the points thus located Some of the results thus obtained are presented as Figs 3, 4, and 5, Plate LVIII, the points representing the actual thickness of the wires being designated by means of small circles It will be seen that all diagrams are plotted with reference to definite wheel positions

The engine as delivered by its builders was balanced for the road, but to increase its steadiness in the laboratory, weights were afterwards added in equal amounts to the several wheels until a full horizontal balance had been secured * The revolving and reciprocating parts which required counterbalancing, exclusive of the crank pins and crank pin bosses which are assumed to be parts of the wheels themselves, were found to weigh as follows —

	lbs
Piston and piston rod	297 0
Cross head with part of indicator rigging attached	170 5
Main rod	344 5
Side rod	278 0
Total for one side.	1 090 0

The corrected net weight of counterbalance available to balance the revolving and reciprocating parts acting upon the crank pins is 550 2 lbs in the main wheel and 539 8 in the rear wheel

The weights of the parts involved, together with certain dimensions, are summarised in Fig 2, Plate LVIII Taking the weights of side rod and of main rod as already given, and considering 0 6 of the weight of the latter as a revolving part, the excess of balance over that required for revolving parts alone is 204 5 for the main wheel, and 400 8 for the rear wheel, which shows 66 per cent of the balance for reciprocating parts to be in the rear wheel

Six different rules for balancing locomotives for the road reported as being in common use, give weights of counterbalance for the locomotive in question ranging from 462 to 588 for the main wheel and from 260 to 381 for the rear wheel, or averages of 548 and 350 lbs, respectively Compared with these several standards the weights of the counterbalances in the Purdue engine average 0 4 per cent too heavy in the main wheel and 54 2 per cent too heavy in the rear wheel It is evident, therefore, that the weight of the counterbalance in the rear wheel from which most of the results about to be discussed were obtained is in excess of that allowed by good practice as expressed by the rules already given But practice cannot always conform to the law by which it assumes to be governed. It often happens where wheels are of small diameter, and the connections are heavy, as in Mogul or consolidation engines, that there is not sufficient room in the main wheel to get in a counterbalance large enough for the revolving parts alone, in this case, therefore, the balance for reciprocating parts of this wheel must be taken by the other coupled wheels in addition to that which, under the rules, would be counted as properly belonging to them By this process, wheels having revolving parts which are relatively light are employed to balance a larger percentage of all the reciprocating weights Again, almost any eight wheel engine balanced in an approved manner will, if the coupling rod is removed, have an excess of balance in the rear wheel equal to that for the engine under consideration and such engines are not infrequently run while disconnected

* The new plant now in operation does not require the locomotive to be in complete horizontal balance.

Attention has already been directed to the fact that in the engine experimented upon the excess of weight in the counterbalance over that required for the revolving parts alone was much greater for the rear driver than for the main driver As the lifting effect is proportional to this excess of weight, it follows that wires run under the rear driver were likely to show more variation in thickness than those under the main driver Results of experiments upon this point are shown by Fig. 3, Plate LVIII, which represents wires obtained at the same instant from the main driver and the rear driver, respectively It will be seen that wire I from the main driver shows but slight variation in thickness, notwithstanding the high speed (312 revolutions per minute), and it may be said that no wire was ever obtained from this wheel which gave evidence that the wheel had left the track From mathematical considerations it can be shown that this wheel would not be expected to lift at speeds below 80 miles per hour (428 revolutions per minute), and such speeds are not practicable with wheels of the diameter experimented upon

Passing now to an inspection of wire II, (Fig 3, Plate LVIII) from the rear wheel which was obtained at the same instant with wire I, it will be seen that there is a jump of the wheel just after the counterbalance has passed its highest point, which, when compared with the corresponding movement of the main driver, is very pronounced Wires from this wheel at higher speeds are shown by Fig 4, Plate LVIII In this figure the full diameter of the wires is in each case shown by a dotted line drawn parallel with the base line Wire III, made at 59 miles (316 revolutions) shows that there was an instant in the passage of the wire, corresponding to the point A, when it was barely touched by the wheel Increasing the speed to 63 miles (337 revolutions) increased the lifting action of the wheel to the extent shown by wire IV, Fig 5 At the point B, the wheel parted contact with this wire and did not again touch it until the point C was reached, an interval of about 40 inches the portion of the wire between B and C being entirely round and apparently unaffected by its passage under the wheel A further increase of speed gives, as is shown by wire V, a still greater length of full wire, the distance from D to E being very nearly equivalent to a quarter revolution of the driver.

It will be seen that all of these wires (II to V, Figs 3 and 4,) substantially agree in showing the maximum lifting effect to occur after the counterbalance has passed its highest point, an effect undoubtedly due to the inertia of the mass to be moved, also in showing that the rise of the wheel from the track is more gradual than its descent The latter condition follows as a sequence of the first

Portions of the wires not shown on the diagrams do not vary much in thickness The metal is rolled so thin by the normal pressure of the wheel that further increments of pressure do not greatly affect it The wires, therefore, do not emphasise the destructive effect of the variation of wheel pressure when the change is insufficient to lift the wheel from the track

It now remains to mention the effect of certain disturbing elements which are shown by the experiments to modify the actual movement of the wheel, other conditions remaining constant For the rear wheel, these disturbing elements are all in the nature of vibrations The first to be noticed is the rocking of the engine upon its springs, which motion tends to vary the pressure of the wheel upon the track independently of the action of the counterbalance At one revolution the effect of the rocking may oppose the action of the counterbalance, and at the next revolution it may supplement the action of the counter balance in producing a vertical movement of the driver. Again, the effect of the rocking may at a given instant be *nil*, and the wheel may rise under the action of the counterbalance but in another instant the effect of the counterbalance and the path of the wheel while in air is modified and its time of descent changed Thus, the existence of this

vibration makes it impossible to duplicate wires with certainty, even though the speed is constant, its effect is well shown by Fig 5 Plate LVIII Wires VI and VII were taken from the rear drivers at the same instant, one from the right side, the other from the left the speed, therefore, must have been the same for both The right driver lacked a good deal of leaving its wire, but the left driver was in air for a tenth of a revolution Again, wires VIII and IX were made in the same way at a higher speed, and here, while both drivers were off the track, the results are reversed, the right driver giving the greater length of full wire It will also be seen from the diagrams that not only is the extent of the vertical movement of the driver modified by the rocking of the engine, but the position of the wheel when such motion occurs is changed It is evident, therefore, that this movement of the engine upon its springs will prove a serious difficulty whenever an attempt is made to predict as to the precise movement of the centre of gravity of the driver, whether the method of investigation be mathematical or experimental

There appears also, to be a vibration of parts, as, for example, of the wheel as a whole, these vibrations being of small amplitude Evidence of the presence of such vibration is shown by the location of points on the diagrams of wires Figs 3 to 5, Plate LVIII which points represent the thickness of the wires as found by measurement Referring especially to wires I and II, Fig 3 it will be seen that the actual thickness of the wire alternately increases and diminishes with every point The time involved in passing from one high point to another (a distance of 10 inches) was about 0 01 second This vibration may be traced on other diagrams its amplitude is from 0 002 to 0 004 in only Whether the process of introducing the wire starts, or has any connection with this vibration, the experiment does not show

A third class of vibrations is made apparent by duplication upon the wire of the reference mark on the wheel As has already been stated, a light nick from a sharp chisel was made across the face of the wheel to serve as a reference mark This nick leaves a clear cut projection upon the wire But at high speeds the single nick across the face of the wheel leaves two projections upon the wire, showing that after making one impression the surface of the wheel must for an instant have actually cleared the wire and then impressed itself a second time The distance between these projections on the wires varies somewhat, but is usually about one eighth of an inch, which represents a time interval between the two impressions of about 0 008 second The contact between wheel and track is therefore not continuous but is a succession of exceedingly rapid impacts These vibrations cannot affect the wheel as a whole, they are doubtless due to the elasticity of the materials, and involve only the parts immediately about the point of contact. The results of the experiments appear to justify the following conclusions :—

1 Wheels balanced according to usual rules (which require all revolving parts and from 40 to 80 per cent of all reciprocating parts to be balanced the counterbalance for the reciprocating parts to be distributed equally among the several wheels connected) are not likely to leave the track through the action of the counterbalance, and cannot do so unless the speed is excessive

2 A wheel which, when at rest, presses upon the rail with a force of 14 000 lbs and which carries a counterbalance 400 lbs in excess of that required for its revolving parts alone, may be expected to leave the truck through the action of the counterbalance whenever its speed exceeds 310 revolutions per minute.

3 When a wheel is lifted, through the action of its counterbalance, its rise is comparatively slow and its descent rapid. The maximum lift occurs after the counterbalance has passed its highest point.

Counterbalancing of Locomotives.

4 The rocking of the engine on its springs may assist or oppose the action of the counterbalance in lifting the wheel It, therefore, constitutes serious obstacles in the way of any study of the precise movement of the wheel

5 The contact of the moving wheel with the track is not continuous, even for those portions of the revolution where the pressure is greatest, but is a rapid succession of impacts

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Third Paper

The third paper to be considered here was the report of a committee on "Counterbalancing Locomotives" presented at the November meeting of the Southern and Southwestern Railway Club, which recorded seventeen different rules for counterbalancing, all extensively used and in this diversity, as well as in the errors of application of the rules, may be found reasons why some roads have had to increase and other roads to reduce the counterbalance weights Each pair of wheels, or, better still each wheel, should be independently balanced within itself for all the rotating or revolving weights attached to its crank pin Rules vary as to how much of the main rod should be considered as revolving weight and how much as reciprocating weight, but the committee considers that these should each be taken at half the weight of the rod for the usual length of rods on road engines, while for very short connecting rods, as on suburban shifting, and Forney engines, especially when the reciprocating parts are heavy, 0 6 of the main rod should be taken as revolving, and 0 4 as reciprocating weights

Another point to be considered in adjusting the counterbalance weights for the revolving parts is the fact that the centrifugal force of the combined weights at the crank pin does not act directly in the plane of action of the counterweights, these latter having to be set back in the wheel so as to clear the side rods, consequently there is a tendency to oscillate or wobble, when a pair of wheels is revolving, which can only be remedied by placing an additional weight in the opposite wheel directly in line with the crank and opposite the counterweight and by proportioning this so that the sum of the weights of the main rod and opposite additional weight will equal that of the counterbalance If the framing, wheels, etc, are designed to withstand the strains caused by steam, they can certainly stand the much smaller strains caused by the weights on the crank pin not revolving in the same plane as the counterweights but it should be borne in mind that the nearer together the planes of rotation of the weights can be brought, the less the disturbing action from this cause will be, therefore, the cylinders of an engine should not be spread one inch further apart than is absolutely necessary. The crank pins should not be made longer than is needed for sufficient bearing surface, and unnecessary collars on the crank pins between the main and side rod brasses and up against the crank hubs, which simply increase the length without answering any useful purpose, should be avoided. The counterbalance weights should also be made to project as far out from the face of the wheel as the rods will permit, with due allowance for clearance. It is a mistake to set them back in the wheels, flush with the spokes although this is a very *prevalent practice*, it being a common thing to find the counterweight in a main wheel projecting an inch or more, and that in the leading and trailing wheel set back flush with the spokes This is wrong They should all be brought out as far as possible, and the front and back counterbalances reduced by taking the weight off the insides or length rather than off the face If the above points are paid attention to the disturbing force due to the different planes of rotation will be reduced to an amount too insignificant to bother further about even on heavy engines

When we come to consider the counterbalancing of the reciprocating weights there are four separate and distinct questions to be answered —

Counterbalancing of Locomotives

1 Can the reciprocating weights be correctly balanced in a horizontal direction by the application of counterweights in the driving wheels?

2 How should the amount of counterweight which is used to counterblance the reciprocating parts be applied, all, in the main wheel? or, divided over all the wheels?

3 What portion of the weight of the reciprocating parts should be counter balanced?

4 What influence does the steam in the cylinders have on the disturbing action of the reciprocating parts and the proper counterbalancing of these?

1—It is first necessary to clearly understand the nature of the disturbing forces produced by the reciprocating motion of the pistons, piston rods cross heads, and front portion of the main rod

These parts acting together have a total given weight, as they change their position with every stroke, the position of their centre of gravity changes relatively to the whole machine, and consequently with every movement of the reciprocating parts, the centre of gravity of the engine changes position, not only fore and aft, but laterally.

At the end of the stroke, although the crank is revolving steadily, the piston is at rest, as the crank pin passes upwards the speed of the piston increases till at half stroke the speed of the piston is equal to the circumferential speed of the crank pin, from there to the end of stroke, the speed of the piston decreases from its maximum to zero The reciprocating weights are, therefore, being accelerated by the crank pin during the first half stroke, and retarded or held back by the crank-pin during the second half As the speed of the piston is zero at the ends of the stroke and maximum at half stroke it follows that the rate of acceleration and retardation must be unequal It is acceleration and retardation which causes the disturbances we are trying to overcome and it has been shown that the effect of a counterweight placed opposite a crank will exactly counteract these disturbances in a horizontal direction, because it of itself produces precisely similar and opposite disturbances that is, when the counterweight and reciprocating weights act in the same plane, which they can never do, as already explained

In a four cylinder engine of the Shaw type, it will be found that the disturbing forces due to the reciprocating weights would neutralise each other on each side of the engine if in the same plane of action but for locomotives of large power, to obtain a counter or over hanging crank of sufficient strength, it is necessary to place the centres of the additional cylinders considerably further apart than the centres of the inner cylinders, and we then have the reciprocating weights and steam pressures acting in different planes thus setting up an unbalanced condition which would require counterweights to correct it The complication, extra number of parts, and essentially weak form of this type of engine, coupled with the fact that it cannot be balanced for the reciprocating weights without some counterweights in the wheels is the reason why these engines have never been brought into general use

It is an utter impossibility to accurately balance the reciprocating weights by counterweights in the driving wheels, on account of the angularity of the main rod. A compromise is necessary, and we take the mean between the two, which is the best that can be done, and which is found by assuming, as before explained, that the main rod is of infinite length, and would, therefore, always be parallel with the centre line of the cylinder

4 The rocking of the engine on its springs may assist or oppose the action of the counterbalance in lifting the wheel It, therefore, constitutes serious obstacles in the way of any study of the precise movement of the wheel

5 The contact of the moving wheel with the track is not continuous, even for those portions of the revolution where the pressure is greatest, but is a rapid succession of impacts

Third Paper

The third paper to be considered here was the report of a committee on "Counterbalancing Locomotives" presented at the November meeting of the Southern and Southwestern Railway Club, which recorded seventeen different rules for counterbalancing, all extensively used and in this diversity, as well as in the errors of application of the rules, may be found reasons why some roads have had to increase and other roads to reduce the counterbalance weights Each pair of wheels, or, better still each wheel, should be independently balanced within itself for all the rotating or revolving weights attached to its crank pin Rules vary as to how much of the main rod should be considered as revolving weight and how much as reciprocating weight, but the committee considers that these should each be taken at half the weight of the rod for the usual length of rods on road engines, while for very short connecting rods, as on suburban shifting, and Forney engines, especially when the reciprocating parts are heavy, 0 6 of the main rod should be taken as revolving, and 0 4 as reciprocating weights

Another point to be considered in adjusting the counterbalance weights for the revolving parts is the fact that the centrifugal force of the combined weights at the crank pin does not act directly in the plane of action of the counterweights, these latter having to be set back in the wheel so as to clear the side rods, consequently there is a tendency to oscillate or wobble, when a pair of wheels is revolving which can only be remedied by placing an additional weight in the opposite wheel directly in line with the crank and opposite the counterweight, and by proportioning this so that the sum of the weights of the main rod and opposite additional weight will equal that of the counterbalance If the framing, wheels etc, are designed to withstand the strains caused by steam, they can certainly stand the much smaller strains caused by the weights on the crank pin not revolving in the same plane as the counterweights but it should be borne in mind that the nearer together the planes of rotation of the weights can be brought, the less the disturbing action from this cause will be therefore, the cylinders of an engine should not be spread one inch further apart than is absolutely necessary. The crank pins should not be made longer than is needed for sufficient bearing surface, and unnecessary collars on the crank pins between the main and side rod brasses and up against the crank hubs, which simply increase the length without answering any useful purpose, should be avoided. The counterbalance weights should also be made to project as far out from the face of the wheel as the rods will permit, with due allowance for clearance It is a mistake to set them back in the wheels flush with the spokes although this is a very prevalent practice, it being a common thing to find the counterweight in a main wheel projecting an inch or more, and that in the leading and trailing wheel set back flush with the spokes This is wrong They should all be brought out as far as possible, and the front and back counterbalances reduced by taking the weight off the insides or length rather than off the face If the above points are paid attention to the disturbing force due to the different planes of rotation will be reduced to an amount too insignificant to bother further about even on heavy engines

When we come to consider the counterbalancing of the reciprocating weights there are four separate and distinct questions to be answered —

Counterbalancing of Locomotives

1. Can the reciprocating weights be correctly balanced in a horizontal direction by the application of counterweights in the driving wheels?

2 How should the amount of counterweight which is used to counterblance the reciprocating parts be applied, all, in the main wheel? or, divided over all the wheels?

3 What portion of the weight of the reciprocating parts should be counter balanced?

4 What influence does the steam in the cylinders have on the disturbing action of the reciprocating parts, and the proper counterbalancing of these?

1—It is first necessary to clearly understand the nature of the disturbing forces produced by the reciprocating motion of the pistons, piston rods, cross heads, and front portion of the main rod

These parts acting together have a total given weight, as they change their position with every stroke, the position of their centre of gravity changes relatively to the whole machine, and consequently with every movement of the reciprocating parts, the centre of gravity of the engine changes position, not only fore and aft, but laterally.

At the end of the stroke, although the crank is revolving steadily, the piston is at rest, as the crank pin passes upwards, the speed of the piston increases till at half stroke the speed of the piston is equal to the circumferential speed of the crank pin, from there to the end of stroke, the speed of the piston decreases from its maximum to zero The reciprocating weights are, therefore, being accelerated by the crank pin during the first half stroke, and retarded or held back by the crank-pin during the second half As the speed of the piston is zero at the ends of the stroke and maximum at half stroke, it follows that the rate of acceleration and retardation must be unequal It is acceleration and retardation which causes the disturbances we are trying to overcome and it has been shown that the effect of a counterweight placed opposite a crank will exactly counteract these disturbances in a horizontal direction, because it of itself produces precisely similar and opposite disturbances that is, when the counterweight and reciprocating weights act in the same plane, which they can never do, as already explained

In a four cylinder engine of the Shaw type, it will be found that the disturbing forces due to the reciprocating weights would neutralise each other on each side of the engine if in the same plane of action, but for locomotives of large power, to obtain a counter or over-hanging crank of sufficient strength, it is necessary to place the centres of the additional cylinders considerably further apart than the centres of the inner cylinders, and we then have the reciprocating weights and steam pressures acting in different planes, thus setting up an unbalanced condition which would require counterweights to correct it The complication, extra number of parts, and essentially weak form of this type of engine, coupled with the fact that it cannot be balanced for the reciprocating weights without some counterweights in the wheels, is the reason why these engines have never been brought into general use

It is an utter impossibility to accurately balance the reciprocating weights by counterweights in the driving wheels, on account of the angularity of the main rod. A compromise is necessary, and we take the mean between the two, which is the best that can be done, and which is found by assuming, as before explained, that the main rod is of infinite length, and would, therefore, always be parallel with the centre line of the cylinder

2—Practice in this respect varies very greatly In England the counterbalance for the reciprocating weights is generally applied at the main wheel, while in this country the weight is generally distributed over all wheels In showing that the disturbances caused by the reciprocating weights were approximately the same as the horizontal component of centrifugal action of counterweights, and could be balanced by one disturbance absorbing the other, we referred only to the horizontal component of the centrifugal force which must receive consideration As long as the counterweights only balance the revolving weights, there could be no downward pressure on the rails or upward pressure on the journal box caused by the vertical influence of the counterbalance, but just as soon as we begin adding weight to the wheels to perfect the balance of the reciprocating weights in a horizontal direction, we correspondingly unbalance the wheels in the vertical direction This is unavoidable and as far as the machine itself is concerned, theoretically it is indifferent whether the whole of the counterbalance for the reciprocating weights be applied in the main wheel or any other wheel, or applied equally or unequally over all driving wheels, the horizontal balance would be equally good, but as the strains have to be transmitted through the frames, axle boxes, wheel castings, crank pins rods, etc, it is evident that the placing of the weight so that the fewest number of parts of the machine will be strained would be the most advantageous, and if we had nothing else but the steadiness of the engine to consider, we would place the whole of the counterbalance for the reciprocating weights in the main wheels, the counter strains would then be transmitted directly through the main pin and main rod to the reciprocating parts without affecting the side rods or frames But by doing so we should unbalance the main wheel vertically very seriously, and not so unbalance the other wheels at all The result would be that the main wheels would strike destructive blows on the rails and bridges at high speeds the tire wear would also be very irregular, flat spots being worn on the main wheel tires

In England where large driving wheels are in general use, where the reciprocating parts *are made very light indeed as compared with the* American practice, and where the weight of rail and strength of bridges are much greater per ton of rolling load than in this country, it may not be objectionable to place all the counterbalance for the reciprocating parts in the main wheel, but here where much heavier engines are used on far lighter rail, and where too many bridges are in need of strengthening and renewing to meet the increased weight of rolling loads which have come with recent years, it is unquestionably proper to divide the amount of counterbalance, which is to be used to correct the disturbances caused by the reciprocating weights, equally between all wheels, so that the downward pressures due to the wheels being out of balance vertically will be distributed over as many points as there are drivers, will be correspondingly reduced in intensity, will be all equal and consequently the rails and floor systems of our bridges will be less severely strained

3—It has already been shown that to obtain practically perfect horizontal counterbalancing for the reciprocating parts, an amount must be added to the counterweights which will counterbalance the entire weight of the piston, piston rod, cross head, and half the main rod D K Clark laid this down as necessary in 1852, and in speaking of the vertical unbalance and the effect of this on track and bridges, dismissed this side of the question with the following words "Its vertical action is insignificant in practice, considering that it has to contend upwardly, with the whole weight of the machine, and downwardly it is met and balanced by the rigidity of the rails" This may have been quite proper in 1852 when the locomotives were quite light and small for the tracks on which they ran, as compared with the immense American engines of to day, and the tracks on which these run. It may be still quite proper in England to concentrate the counter-

balance for the reciprocating weights in the main wheel on account of the lightness of the parts and relative strength of the tracks there, but unless we are misinformed, engines so balanced have caused much trouble on the lighter rails and imperfect tracks in Australia In England some of the best roads running the fastest trains, where the conditions are far more favorable for full balancing than they are in this country, only find it necessary to counterbalance 50 per cent of the reciprocating weights

Some reports of bent rails having been sent in on a prominent western road, an investigation was held, and it was found that additional weights had been added to the main wheels of some of the older engines by one of the master mechanics because the engine rode hard It was found that one of these engines which had been tinkered with in this way had considerably more balance than was needed to counterbalance the reciprocating weights, and it was excessively out of balance vertically in consequence It was further found that rail pressures produced by this vertical unbalance would at 60 miles per hour, amount to 34,600 lbs. for each main wheel for each revolution, and by actual drop test it was found that this was more than enough to produce bad kinks in a new 60 lb rail supported on ties 18 inches apart. In the test of this engine when slung from the cranes, it was found that the oscillation was not materially different in extent when the engine was slightly overbalanced *for the full amount of the reciprocating weights,* and *when the weights were* so reduced that only 33 per cent of the reciprocating weights were balanced, the main disturbance in the former case, however, was fore and aft and rolling, while in the latter case it was by nosing It was found to be unsafe, however, to run the engine in either case faster than 28 or 30 miles per hour, on account of the excessive vibration of the cranes and building

In an instance which came to the notice of your committee where the lead had been unintentionally omitted from two of the counterbalances of one engine of a group of five running in chain-gang service, careful observation failed to show that there was any perceptible difference in the riding, not one of the enginemen handling these engines noticed the absence of the lead or made a complaint of the engine And after months of service, careful inspection showed that the engine had not suffered in the slightest in wear, or otherwise on account of the omission Again, we have positive evidence that one lot of heavy consolidation engines were sent into service with only sufficient counterbalance to balance 2 per cent of the reciprocating weights, and were all so rough when running fast, that they shook their cabs to pieces in no time, and the men could not sit down on the cab seats Again, it is claimed that some of the world's records for high speeds recently have been made with engines fully counterbalanced for their whole reciprocating weights This is no doubt true, but it must be remembered that the tracks on which these engines are run are exceptionally heavy for this country, and until the question as to whether these same engines would not make faster time with greater ease if the counterbalance is reduced, we must allow that the weight of the evidence is against full balancing on modern heavy engines One of your committee knows from personal experience that some of these fully-balanced engines running at 70 miles per hour and over (while there was little lateral oscillation) are exceedingly rough riders, jarring the spine so that at the end of a long run one is in a state of abject collapse Taking everything into consideration, your committee believes that the weight of the testimony is against the practice of providing full balance for the full reciprocating weights That on locomotives of the design and weight prevalent a few years ago, probably the best proportion of the reciprocating weights to balance is about two thirds and the same rule can be followed with engines having an exceptionally small wheel base and long over hanging ends such as shifters for use on sharp curves That for modern locomotives of heavier designs for road service it is believed that to provide counterbalance for 50 per cent of the reciprocating weights, will give a good riding, well balanced engine, which will not be so severe on

the tracks and bridges at high speeds, and the tires of which will wear more evenly But that with compound engines, having excessively heavy reciprocating parts as compared with their total weight the proportion of reciprocating weights to be counterbalanced should be between 60 per cent. and 75 per cent according to circumstances Incidentally we found a variation of 24 lbs in the finished weights of 20 inch pistons cast from the same patterns

4—All locomotives have to make a good portion of their mileage drifting down grades with steam shut off, and the balance must be so arranged that the engine will run *smoothly under these conditions, as well as when steam is being used* For a well-designed modern locomotive the disturbing influence of the reciprocating parts at the highest speeds is not much over half the pressure in a horizontal direction that is exerted by the steam along the same lines of action. With short cut offs there are times when the steam works against the disturbing force, and others when it works with it, and these conditions vary constantly, according to the cut off and throttle opening at any particular rate of speed It is an interesting study to represent by diagram the rotative effect of the crank circle at every degree of the revolution due to the action of the steam and reciprocating parts, but it is too elaborate an investigation to bring into this report Suffice it to say that for short cut offs, such as are used at high speeds the acceleration of the reciprocating parts comes into play much as a flywheel does in a stationary engine to regulate the turning moment on the crank axle and generally speaking, the action of the steam helps to cushion and distribute the disturbing action of the reciprocating parts, as also to take up the slack gently at the proper times and prevent heavy pounding especially when the compression line of the indicator diagram is well adjusted, but the steam cannot counterbalance the disturbing effects of the reciprocating parts, it simply modifies their effects It is too often the case that engines are reported riding roughly and needing more counterbalance, when the fault is in the defective valve motion, excessive or insufficient compression, too much lead or some similar troubles , and the counterbalance should not be interfered with until indicator diagrams have been taken from the engines and the valve motion adjusted so as to give a proper exhaust, compression and pre-admission for the conditions under which the engines are expected to work This is rarely done but instead, the master mechanic commences to tinker with the counter balances adding and taking off weights by guess work until the engineman is satisfied, when as often as not they have been trying to correct a bad steam distribution by spoiling the counterbalancing

The report may be summarised as follows —

1 Each wheel should be balanced correctly for all the revolving weights attached to it

2 The main rod should be considered as half revolving and half reciprocating weight when over 8 ft long , if under this it should be considered as 0 6 revolving and 0 4 reciprocating weight

3 The part of the weight of the main rod considered as revolving weight should be entirely balanced in the main wheel

4 The amount of overbalance to be applied to the drivers to balance the reciprocating weights should be equally divided between all the driving wheels

5 For modern heavy well designed locomotives, with comparatively light reciprocating parts provide counterbalance for 50 per cent of the reciprocating weights.

6 For lighter engines, that are less able to withstand strains and absorb the disturbances *caused by heavy reciprocating parts*, or for such as have *very short wheel base and* long overhang balance up to 66 per cent of the reciprocating weights

7 For compound engines, with large pistons, and excessively heavy reciprocating parts, balance up to 75 per cent of the reciprocating parts

8. The centre of gravity of the counterbalance weight must be opposite the crank

9 The counterbalance should be brought out from the face of the wheel as far as due clearance for the rods and good design of wheel will permit

10 The centre of gravity of the counterweight should be placed as near the rim as possible, and the bulk of the counterbalance made as small as possible This can be accomplished by the use of lead filling, and by making the counterweights as at A, rather than as at B, Fig 6, Plate LVIII

11 If, on account of the smallness of the wheels, sufficient counterbalance, according to the rules given above cannot be placed in the main wheels, then add up to 50 lbs to the weight in each of the other wheels to help balance the right amount of the reciprocating weights, but the excess should in no case exceed this amount

12 Make *the reciprocating parts* as light as possible

In the discussion on the paper by Professor Goss, given last week, Mr Geo S Morison said it is important to eliminate from track and bridges the great variation in pressure due to faulty counterbalancing Mr Strong said that, even when the wheel is not lifted from the track, there is the effect of a blow The variation in pressure may decrease the traction and give the wheel a tendency to slip. Another member said that he believed fully one third of the repairs to engines and wear and tear of track are due to unbalanced reciprocating parts Mr F W Dean said he had noticed, in riding on engines, much vertical vibration, which he could account for only by the wheels leaving the track Below and above a speed of 60 miles an hour this vibration was not noticeable He further stated that Mr Strong has made studies for an engine which appears likely to overcome vibration perfectly Mr M N Forney said he also was designing a locomotive to overcome the difficulties under discussion He thought it was fair to infer from Mr Goss' paper that the engine in question was overbalanced

Mr Morison stated that on railways passing through hilly country almost all bent rails are between two hills, where the highest speeds are attained Mr Strong confirmed this statement and referred to a rolling motion of the locomotive, which causes the bends to be down and in, the bends never being outwards

In the discussion on Mr Barnes' paper, on ' Railway Locomotive Driving Wheels,' abstracted last week Mr Strong said that Mr Barnes' method of overcoming the difficulty is by reducing the weight of the reciprocating parts and by large driving wheels Fast trains must have engines with high piston speeds, which require heavy reciprocating parts Mr Strong thought that for American roads 5 feet wheels are better than 7 feet wheels The cost of locomotives is nothing compared with the expenses caused by bad track, resulting from poor balancing In response to a request from the President-elect, Mr Davis Mr Strong gave a brief description of his new locomotive, soon to be tested. It will be a four cylinder balanced engine with a crank shaft of nickel steel

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THE WEAR OF DRIVING WHEEL TIRES

Report of the Committee at the Twenty eighth annual Convention of the American Railway Master Mechanics Association June 1895

Your Committee on the Wear of Driving Wheel Tires, as affected by weight upon same, have collected a large amount of information concerning the wear of driving wheel tires most of which was gathered by the different members of your Committee from actual experience and records kept of accurate measurements made of the amount and location of irregularities of wear in tires of a number of the different classes of engines coming into the principal shops of the Chicago Burlington & Northern, and Chicago, Milwaukee & St Paul railways during the past five years as well as from records of the comparative wear of driving wheel tires on the Union Pacific Railway from engines in service during the past twenty two years

This report naturally divides itself into three parts

1st—The nature, location and extent of the irregularities in the wear of driving-wheel tires and methods employed in measuring and diagraming them

2nd—A discussion of the forces causing or tending to cause the wear of locomotive driving wheel tires in both the ordinary American eight wheel and ten wheel type of engine

3rd—Deductions and conclusions of your Committee based upon the above data

The published proceedings of the following meetings of the Western Railway Club contain a mass of information and data in papers and discussions on this subject, which has been freely used by your Committee April and May, 1890 January and February 1891 and May and September, 1892

The nature location and extent of the irregularities in the wear of driving wheel tires have been carefully studied from measurements made and diagrams taken from a large number of engines in different classes of service, both on the C, B & N and C M and St P railways

Appendix A (page 283 85) gives the location and depth of the spots of greatest wear on the driving wheel tires of C, B & N engines, arranged in groups, as follows

Twelve 4 8 Class A passenger engines Nos 1 to 12, with 63 inch driving centers

Twenty three 4 8 Class A freight engines, Nos 50 to 72, with 57 inch driving centers

Fifteen 6 10 Class B freight engines, Nos 150 to 164 with 56 inch driving centers

Six 4 4 Class E switch engines, Nos 100 to 105 with 44 inch driving centers

The general dimensions, weights, etc, of these engines are as follows

	CLASS A	CLASS A	CLASS B	CLASS E
Service	Passenger	Freight	Freight	Switch
Cylinders	18×24 in	18×24 in	19×24 in	16×22 in
Steam pressure	145 lbs	145 lbs	150 lbs	130 lbs
Diameter, driving centers	*63 in*	*57 in*	*56 in*	*44 in*
Driving-wheel base	8 ft 6 in	8 ft 6 in	15 ft 6 in	7 ft 6 in.
Length of main rod	7 ft 3½ in	7 ft 3½ in	10 ft	7 ft 6½ in
Diameter piston rods	3 in	3 in	3¼ in	2¾ in
Weight on drivers	54 000 lbs.	54 000 lbs	90 000 lbs	60,000 lbs
Weight of reciprocating parts	513 lbs	513 lbs	684 lbs	...

Plates LIX to LXII show typical diagrams taken from the tires of engines in each of the above classes

These diagrams were taken by an instrument devised by Mr W H Lewis, and which is illustrated in Figs 3, 4 and 5 on Plate LXII. The instrument consists of a revolving disk secured to the tool post of the driving wheel lathe, connected by shaft and gear to the gearing on the lathe face plate The motion of the disk is reduced to the same speed as the lathe, and by the aid of the two-pinion gear is made to revolve *in the same direction as the lathe, when the instrument is changed from one wheel to* the other The pencil bar is set with the pencil at the center on the disk, and the end of bar at the inside diameter of the tire The bar is then placed on the tread of the tire, and held to the tread by a spiral spring and the lathe allowed to make one revolution, thereby drawing a profile of the tread on the paper attached to the disk, the radius of the circle drawn representing accurately the thickness of the tire In our engravings Fig 3 shows an end elevation, Fig 4 a side elevation, and Fig 5 the instrument in position on the *tool post and secured to same by the tool clamps* *AA* is a gear which meshes with the rack gear on the face plate of the lathe and revolves the disk *B* is the pencil bar which is held to the tread of the tire by the spring *E* *C* is the pencil. *DD* are spring clips that hold the indicator card in position on the revolving disk, as shown in Fig 3 In order that all the diagrams may be taken with the disk revolving in the same direction as the driving wheel, it becomes necessary to reverse the motion when the instrument is turned around in changing it from one tool post to the other. This is accomplished by reversing the small pinions marked *L* and *R*

From this description it is plain that the diagrams in Plates LIX to LXII show not only a diagram of the contour of the tread of the tire, but its thickness as well In the arrangement of these diagrams, the engine is supposed to be standing with its right side presented. In locating the flat spots, zero is taken on the tire at its point of contact with the rail when the right crank is on the forward center, positive rotation being *that* produced by running the engine forward The radius of the largest circle is the actual thickness of the tire when new The radius of each smaller circle shows the thickness at the thickest point before turning The irregular circular lines show the actual contour of the tread as worn, and the difference between this line and the circle next larger shows the actual depth of wear below the least worn point at every point of the circumference of the tire The sections at the right and left show the cross sections at point of greatest wear, and serve to show the maximum actual wear between turnings The dates of each turning and amount the tire was reduced are also given, together with the mileage between turnings and mileage per $\frac{1}{16}$ inch

Referring to Plate LXI, the diagram of the tire of Engine 150 it is important to note the slight effect a considerable change in the amount of counterbalance in a driving wheel makes upon the location and extent of irregularities of wear The dotted line on the diagram of the main tire shows the contour before turning after the engine had been

in service, with almost the entire weight of the reciprocating parts balanced After this turning the excess counterbalance 585 pounds, was removed from the front and back wheels reducing in them the counterbalance to that necessary to balance the revolving weights only The main drivers were also reduced to but 44 pounds in excess of the revolving balance The next irregular line shown on this plate shows a diagram of these tires since the change, which gives especially in the main wheels almost an exact reproduction of the irregularities of wear shown at the first turning The counterbalance was then replaced, and the next two contour lines show the result at the next turning

Plate LXII, Fig 1, shows the very slight irregularity of wear of switch engine tires, due doubtless, to their being run backward about as much as forward The same is found to be also true of suburban engines, running both forward and backward

This plate, Fig 2 also shows a diagram of the average wear of the tires on fifty three C, M & St P ten wheel freight engines of the following dimensions

Cylinders, 19 x 26 inches
Steam pressure 150 pounds
Diameter driving centers 56 inches
Length of main rod 10 feet
Diameter piston rod, 3½ inches
Weight on drivers, 84 000 pounds
Weight of reciprocating parts, 729 pounds

The piston, piston rod crosshead and front end of the main rod are taken as reciprocating parts, the back end of main rod as a revolving weight in all calculations which follow

The weights of the ends of the rods were found by supporting each end at the centre of the box or bearing, and resting them alternately on scales

The diagrams were obtained as follows

Each pair of tires when placed in the lathe were rotated until the highest point of worn tread was found A bar of steel with the end cut off square, was placed in the tool rest, and after being brought against the highest spot on the tread was securely clamped The wheel is then rotated if necessary to bring the 0° point opposite the end of this bar The depth of wear below the highest point is then measured in hundredths of an inch by inserting as many metal strips each exactly $\frac{1}{100}$ inch thick, between the bar end and tire as the space will admit Similar measurements every 10° around the wheel were made An average of the measurements so taken for fifty three engines is plotted on Plate LXII Fig 2 each tire being considered developed on the datum line, and the amount of wear in $\frac{1}{100}$ inch plotted therefrom The diagrams of wheels on this sheet show clearly the position of the irregularities of wear of each tire with reference to the crank pins and counterbalance

Appendix B contains a record of the wear of tires on eight wheel Union Pacific engines all having the same size driving wheels and all run in passenger service, but on schedules of different speeds and having different cylinder power and weight on drivers. This sheet also gives the principal dimensions, weights and steam pressure carried, together with the average time card speed of the trains hauled The great variation in *the amount of mileage per* $\frac{1}{16}$ *inch of wear of* tires under the lighter and heavier engines is clearly shown, the 16 x 24 inch engines weighing 42 800 pounds on drivers, averaging 14 722 miles per $\frac{1}{16}$ inch of wear while the 18 x 26 inch engines weighing 69 300 pounds on drivers, only averaged 6,717 miles per $\frac{1}{16}$ inch of wear

It should be carefully remembered, however, that the average speed at which these *engines were run is by no means the same, but that the lighter engines generally ran on* slower schedules Where this is not the case, the engines on the fastest schedule show the greatest wear, even when the weight on the drivers is less When the speed is the same, the most rapid wear is found on those engines having the heaviest wheel weights

Plates LIX to LXII, inclusive, show very clearly the extent and general location of the irregularities in the wear of the tires on engines of both the eight and ten-wheel type Before the causes of these peculiarities of wear can be intelligently discussed, an accurate understanding of the forces in action and producing, or tending to produce, wear of driving wheel tires, should be had This brings us to the second part of our report

The calculations which follow were all made from data obtained from eight and ten-wheel engines on the C, M and St P R R The engines for which these calculations were made are known as Class B, a 4 8 American type locomotive, built by the St Paul Co, and Rhode Island and Schenectady 6 10 engines of similar design and construction. The following are the principal dimensions and weights of each

	CLASS B	TEN WHEELERS.
Cylinders	16×24 in	19×26 in
Steam pressure	160 lbs	150 lbs
Diameter driving centers	56 in	56 in
Driving wheel base	8 ft. 6 in.	
Length of main rod	7 ft $2\frac{3}{8}$ in	10 ft
Diameter piston rod	$2\frac{3}{4}$ in	$3\frac{1}{4}$ in
Weight on drivers	54 000 lbs	84 000 lbs
Weight of reciprocating parts each side	480 lbs.	729 lbs.

The eight-wheel engines had the entire weight of the reciprocating parts balanced, by adding one half this weight in each driving wheel to the weight necessary to balance the revolving parts when weighed at the crank pin The ten wheel engines were not counterbalanced alike, but all agreed in having the forward and back wheels over-balanced—that is with a heavier counterbalance than that required to balance the revolving parts only, while the main wheels of thirty five of the fifty three engines from which measurements were taken were underbalanced for the revolving parts alone, and all of them underbalanced according to the rule of adding to the weight necessary to balance the revolving parts two thirds of the weight of the reciprocating parts divided equally between the driving wheels The counterbalance in the wheels of each of these engines was carefully weighed by resting the journals of each pair of drivers on level straight edges, placing the crank horizontally and hanging on the crank pin a sufficient weight to just balance the counterbalance opposite From this weight, the weight of the revolving parts attached to that pin were subtracted the remainder being the amount of over-balance weighed at the crank pin If the weight of the revolving parts exceeded the weight so found, of course the wheel was underbalanced by the amount of such excess The actual average *condition of the counterbalance in the wheels of the fifty three* ten-wheelers taken as they came into the West Milwaukee shops for general repairs, was as follows Average overbalance weighed at the crank pin above that required to balance revolving parts only—

Front wheel, 271 pounds overbalance

Main wheel, 80 pounds underbalance

Back wheel, 237 pounds overbalance

These weights are used in all the calculations for the ten-wheel engines which follow

The forces in action in a locomotive which we have thought it necessary to determine are

1st The actual pressure of each driving wheel upon the rail during an entire revolution at different speeds

in service, with almost the entire weight of the reciprocating parts balanced After this turning, the excess counterbalance, 585 pounds, was removed from the front and back wheels, reducing in them the counterbalance to that necessary to balance the revolving weights only The main drivers were also reduced to but 44 pounds in excess of the revolving balance The next irregular line shown on this plate shows a diagram of these tires since the change, which gives, especially in the main wheels, almost an exact reproduction of the irregularities of wear shown at the first turning. The counterbalance was then replaced, and the next two contour lines show the result at the next turning.

Plate LXII, Fig 1, shows the very slight irregularity of wear of switch-engine tires, due, doubtless, to their being run backward about as much as forward The same is found to be also true of suburban engines, running both forward and backward.

This plate, Fig 2, also shows a diagram of the average wear of the tires on fifty-three C, M. & St P ten-wheel freight engines of the following dimensions.

Cylinders, 19 x 26 inches
Steam pressure 150 pounds
Diameter driving centers, 56 inches.
Length of main rod, 10 feet
Diameter piston rod, 3½ inches
Weight on drivers, 84,000 pounds
Weight of reciprocating parts, 729 pounds

The piston, piston rod crosshead and front end of the main rod are taken as reciprocating parts, the back end of main rod as a revolving weight, in all calculations which follow

The weights of the ends of the rods were found by supporting each end at the centre of the box or bearing, and resting them alternately on scales

The diagrams were obtained as follows

Each pair of tires when placed in the lathe were rotated until the highest point of worn tread was found A bar of steel, with the end cut off square, was placed in the tool rest, and after being brought against the highest spot on the tread was securely clamped The wheel is then rotated, if necessary, to bring the 0° point opposite the end of this bar The depth of wear below the highest point is then measured in hundredths of an inch by inserting as many metal strips, each exactly $\frac{1}{100}$ inch thick, between the bar end and tire as the space will admit Similar measurements every 10° around the wheel were made An average of the measurements so taken for fifty-three engines is plotted on Plate LXII, Fig 2, each tire being considered developed on the datum line, and the amount of wear in $\frac{1}{100}$ inch plotted therefrom The diagrams of wheels on this sheet show clearly the position of the irregularities of wear of each tire with reference to the crank pins and counterbalance

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It should be carefully remembered, however, that the average speed at which these engines were run is by no means the same, but that the lighter engines generally ran on slower schedules Where this is not the case, the engines on the fastest schedule show the greatest wear, even when the weight on the drivers is less When the speed is the same, the most rapid wear is found on those engines having the heaviest wheel weights

Plates LIX to LXII, inclusive, show very clearly the extent and general location of the irregularities in the wear of the tires on engines of both the eight and ten-wheel type Before the causes of these peculiarities of wear can be intelligently discussed, an accurate understanding of the forces in action and producing, or tending to produce, wear of driving-wheel tires, should be had This brings us to the second part of our report.

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Driving wheel base	8 ft 6 in	
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Diameter piston rod	2⅞ in	3¼ in
Weight on drivers	54 000 lbs	84 000 lbs
Weight of reciprocating parts each side	480 lbs.	729 lbs

The eight-wheel engines had the entire weight of the reciprocating parts balanced, by adding one half this weight in each driving wheel to the weight necessary to balance the revolving parts when weighed at the crank pin The ten wheel engines were not counterbalanced alike, but all agreed in having the forward and back wheels over-balanced—that is, with a heavier counterbalance than that required to balance the revolving parts only, while the main wheels of thirty five of the fifty three engines from which measurements were taken were underbalanced for the revolving parts alone, and all of them underbalanced according to the rule of adding to the weight necessary to balance the revolving parts two thirds of the weight of the reciprocating parts divided equally between the driving wheels The counterbalance in the wheels of each of these engines was carefully weighed by resting the journals of each pair of drivers on level straight edges, placing the crank horizontally and hanging on the crank pin a sufficient weight to just balance the counterbalance opposite From this weight, the weight of the revolving parts attached to that pin were subtracted, the remainder being the amount of over-balance weighed at the crank pin If the weight of the revolving parts exceeded the weight so found, of course the wheel was underbalanced by the amount of such excess The actual average condition of the counterbalance in the wheels of the fifty three ten-wheelers taken as they came into the West Milwaukee shops for general repairs, was as follows *Average overbalance weighed at the crank pin above that required to balance revolving parts only*—

Front wheel, 271 pounds overbalance

Main wheel, 80 pounds underbalance

Back wheel, 237 pounds overbalance

These weights are used in all the calculations for the ten-wheel engines which follow

The forces in action in a locomotive which we have thought it necessary to determine are

1st The actual pressure of each driving wheel upon the rail during an entire revolution at different speeds

2nd The total rotative force at the rail during an entire revolution, and for the same speeds as the pressures were calculated

The following formulæ have been used in calculating the forces in action

Notation.

P=Pressure of one driving wheel on rail

R=Rotative force at the rail from one cylinder.

W=Weight of each wheel on rail, engine at rest

C=Centrifugal force of the excess weight in the counterbalance over that required to balance the revolving parts

A=Acceleration or retardation of the reciprocating parts

p=Pressure against crosshead pin from steam in cylinder.

a=Angle of the crank with the horizontal.

N=Ratio of length of main rod to length of crank.

s=Length of the stroke

D=Diameter of drivers.

Hence—

$$P=W-C\sin a+\frac{(p-A)}{\sqrt{\frac{N^2}{\sin^2 a}-1}} \qquad (1)$$

$$R=(p-A)\left(\sin a+\frac{\operatorname{Cos} a}{\sqrt{\frac{N^2}{\sin^2 a}-1}}\right)\frac{S}{D} \qquad (2)$$

As C and A have to be calculated before the above formulæ can be used, the following notation and expressions for them are given

w=Weight of the excess in the counterbalance over that required to balance the revolving parts

v=Velocity of the centre of gravity of the overbalance

r=Radius of the centre of gravity of the overbalance.

w'=Weight of the reciprocating parts

v'=Velocity of the crank pin.

l=Length of the crank

g=The acceleration of gravity 32 16.

Hence

$$C=\frac{w\,v^2}{g\,r} \qquad (3)$$

$$A=\frac{w\,v'^2}{g\,l}\operatorname{Cos} a \qquad (4)$$

or by substituting in (1) and (2) we have

$$P=W-\frac{w\,v^2}{g\,r}\sin a+\frac{\left(p-\frac{w'\,v'^2}{gl}\operatorname{Cos} a\right)}{\sqrt{\frac{N^2}{\sin^2 a}-1}} \qquad (5)$$

$$R=\left(p-\frac{w'\,v'^2}{gl}\operatorname{Cos} a\right)\left(\sin a+\frac{\operatorname{Cos} a}{\sqrt{\frac{N^2}{\sin^2 a}-1}}\right)\frac{S}{D} \qquad (6)$$

The above formulæ include the centrifugal force of the overbalance in the drivers, the effect of the acceleration and retardation of the reciprocating parts and the angularity of the main rod Formula (4) for the acceleration of the reciprocating parts assumes that they move as they would were the main rod infinitely long but the error this produces is too small to affect the accuracy of the results while the formulæ are much simplified

The point of 0° is taken in all tables and diagrams that follow at the point of contact between tire and rail when the right crank is on the forward centre positive rotation being that produced by running the engine forward

The values of *P* and *R* have been calculated for every 10° of revolution for each wheel of the eight and ten-wheel engines for the following speeds

Eight wheel engine just starting, 40 miles per hour, 60 miles per hour

Ten wheel engine, just starting, 10 miles per hour, 20 miles per hour, 30 miles per hour, 40 miles per hour, 60 miles per hour *

The pressures upon the piston used in these calculations were obtained from actual indicator cards taken at these speeds, and with a point of cut off found by the examination of a large number of cards to be the usual point at which an engine is worked at the speed taken The points of cut off used are

Eight wheel engine, just starting, 22", at 40 miles per hour, 6", at 60 miles per hour 6" *

Ten-wheel engine, just starting, 22", at 10 miles per hour 13", at 20 miles per hour, 11", at 30 miles per hour, 8", at 40 miles per hour, 6", at 60 miles per hour, $5\frac{3}{8}$" *

The results of these calculations for each of the wheels on the eight-wheel engines are shown in Tables and graphically in Plates LXIII to LXV, and for the ten wheel engines in Tables, also graphically in Plates LXVI to LXVIII †

The Columns in the Tables give (7) the total weight of all drivers on the rail, (8) the total rotative force of both cylinders at the rail, and (9) the ratio of 8 to 7 (called in this report "the co efficient of slip"), respectively Since the co efficient of slip is the rotative force at the rail divided by the total weight of drivers on the rail, it is plain that as this co efficient increases, the tendency of the drivers to slip increases, and when it just equals the co efficient of friction between the tire and rail, the engine is on the point of slipping Therefore, the maximum values of the co efficient of slip indicate the point where the engine is most likely to slip the drivers

The values in Columns 7, 8 and 9 of the Tables have been plotted in the Plates, and these curves have been given numbers corresponding to the numbers in the column in which the values of their ordinates are shown

Thus the curve corresponding to Column 2 of Table M is shown on the diagrams as 2 M etc

An inspection of the Curves 7 M to 7 X shows the wide variation in the total pressure of the drivers on the rail At speeds no higher than forty miles per hour with a freight engine balanced much better than many in regular service this pressure varies from 75 355 lbs to 97 536 lbs a variation of more than 22,000 lbs each revolution, while at sixty miles per hour the pressure of each revolution varies nearly 51,000 lbs, from a *minimum of 60,143 lbs to a maximum of 111 054 lbs This variation of pressure each* revolution is almost entirely due to the centrifugal force of the overbalance, or what is usually spoken of as a hammer blow As this varies as the square of the speed, the importance of keeping the overbalance in high speed engines as low as possible is very evident This means reducing the weight of the reciprocating parts to a minimum and adding to the counterbalance necessary to balance the revolving weights as small a part

* The diagram at 60 miles an hour is not reproduced.

† The tables have not been reprinted, as the plates give all the information.

of the weight of the reciprocating parts as is consistent with a good riding and smooth-working engine

Curves 7 S, 7 T and 7 U, for speeds of just starting ten and twenty miles per hour, show that the total pressure of drivers on the rail is always greater at these speeds and cut-offs than the actual weight of drivers on the rail, engine at rest. This is due to the angularity of the main rod always causing an increase of pressure on the main wheel There is of course, a corresponding upward pressure on the guides, reducing the weight on the truck

Curves 8 M to 8 X are interesting in showing the variation in the rotative or tractive force of the engine at various speeds and different points of cut off These indicate that an engine would pull more steadily at speeds between ten and twenty miles per hour than at either higher or lower speeds The rotative force is, of course, affected by changes in the cut off but at high speeds the inertia of the reciprocating parts becomes the more important, and materially affects the steadiness of the engine, regardless of the amount of steam worked This is readily seen in any engine by an inspection of the diagram of a dynamometer car taken at high speed

Curves 9 M to 9 X give the ratio of the rotative force to the weight on rail—here called the co efficient of slip The maxima of this curve follow quite closely the maxima of the curve of rotative force The maximum value for speeds shown occurs between 130° and 140°

The third part of this report is approached by your Committee with a full realization of the very complicated action of the forces and causes bringing about irregularities in the wear of tires, and what follows is the result of our study and observations on the large number of tires examined Local peculiarities of the tire, such as soft spots in it as well as flat spots caused by slight sliding, affect the final contour of a worn tire, and it is only by taking the average wear at the same points on a large number of tires that the irregularities due to general conditions show themselves with the necessary clearness on which to base a theory for their cause

In this discussion we will therefore, refer principally to the diagram of the average wear of the tire of the fifty three C, M and St P ten wheel engines shown on Plate LXII

First we will consider the wear of the front and back tires only as these wheels were overbalanced, the main wheels being underbalanced and, on account of the effect of the angularity of the main rod subject to quite different conditions from the others Directing our attention to the wheels on the right side of the engine an inspection of the Plate shows quite uniformly in both right forward and back tires, two locations of maximum wear, one beginning at about 160° and attaining its maximum at 220° or 230°, the other becoming pronounced at about 10° or 20° and attaining its maximum at about 50° It will also be noticed that both of these low spots are connected from 220° to 50° in the direction of rotation by a portion of the tire much more worn than that portion from 50° to 220°. To understand the cause of this irregular wear, it is necessary to bear in mind that there are at least two ways in which driving wheels are slipped first, when the slipping is slightly but distinctly noticeable extending through but a small portion of a revolution second, when the hold on the rail is entirely broken and the wheels slip through a number of revolutions, usually turning with considerable velocity

The first case of slipping through but a small part of a revolution occurs almost without exception on heavy pulls at slow speed being often seen when an engine is

pulling hard on a hill with just enough sand being used to avoid serious slipping but not enough to prevent a slight slip at points where the rotative force is the greatest The beginning of slip must occur under these conditions at or near a maximum of the co efficient of slip Referring to Plate LXVI, we find a maximum value of the co efficient of slip at 40° to 50° and 130° to 140° with engine just starting At 20 miles per hour, the maxima are at 40° and 130°, and at this speed the tendency to slip at 100° is also almost as great as at the other points Plate LXII shows a small spot following 100° on the front right tire, but none is seen on the back. Curves 3 U and 4 U on Plate LXVII indicate the cause, as the pressure of these wheels upon the rail at 100° is almost at a minimum, and is much less than at 140° to 160° It is also noticeable that the amount of wear following 160° is greater than that following 40° or 50° for the same reason This variation in pressure upon the rail increases rapidly with the speed and Curves 3 and 4 Plates LXVII and LXVIII, show very clearly that following 40° the pressure of the front and back wheels on the right side decreases very rapidly, while the reverse is the case following 160°

The same conditions as to pressure on the rail occur for the left-hand forward and back wheels just 90° back of those on the right side, and irregularities of wear produced by the drivers slipping through a number of revolutions at considerable velocity should occur on the left wheels at points 90° back of the corresponding points on the right wheels, 90° back of 40° is 310°, and 90° back of 220° to 230° is 130° and 140° Plate LXII shows the greatest depth of wear of tires of the left front and back wheels to be almost exactly at these points There is also a smaller spot worn at 40°, due to the slipping at slow speeds when the influence of the counterbalance is nil

The irregularities of wear of the main wheels follow the same law as those of the front and back wheels, but the conditions are considerably modified by the difference in pressures caused by the influence of the angularity of the main rod, and to a less degree from these wheels being under instead of over balanced

The spots caused by the slight slipping at slow speeds at about 40° and 130° should be found in these wheels as in the front and back wheels unless the accompanying condition of necessary pressure is absent Curves 3 and 5 on Plates LXVI to LXVIII show from 16 500 to 17,000 pounds at 40° on the right main wheel and from 12 700 to 17 500 pounds on the left wheel at the same point, indicating greater wear on the right than the left tire at this point, which the diagram, Plate LXII shows The wear at 130° is found in these wheels, but, owing principally to the influence of the angularity of the main rod and partly to the wheels being underbalanced, the conditions of pressure following 130° on the right main wheel are very different from that of the right front and back wheels The diagrams show that the pressure on this wheel is always rapidly decreasing following 130° instead of increasing, and consequently the worn spot at this point Plate LXII, extends but a short distance in the direction of rotation Not so, however, with the left main tire Here the pressure is always increasing following this point, and Plate LXII shows the great elongation of this spot in the direction of rotation, extending it as far as 210°, while that on the right tire extends only to 165°

There still remains to be explained why the heavy spot on the main tires should slightly precede the point of the maximum co-efficient of slip at 130°, and why that on the left wheel still further precedes this point and in general is greater than on the right. An inspection of Curves 2S to 2X shows that the pressure of the right main wheel on the rail is always greater preceding than following the 130° point. Curves 9S to 9X also show that the co efficient of slip is high as early as 110° after a speed of 10 miles per

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hour is attained, and increases but slightly to its maximum at about 130° Any slipping occurring between 110° and 130° will, on account of the pressure, cause a serious spot at this point on the main wheels, which the diagram shows

Plate LXII shows the worn spot under consideration on the left tire, not only elongated in the direction of rotation, which is explained by the difference in pressure in this direction but also in the opposite direction, extending beyond the 80° point This is doubtless due to the slight slip caused by the main rod passing the forward centre and suddenly thrusting this wheel back an amount equal to the lost motion in the bearing shoe and wedge The same thing occurs, of course, on the right wheel, and the sharp but slight wear following the 350° point shows it quite clearly. On the left wheel, however, this wear is immediately followed by the more serious one due to the approach of the maximum point of co-efficient of slip from 110° to 130°, and becoming merged into *it both are increased*

On the bottom of Plate LXIV is shown the wear of the tires on St Paul engine 316, for which the calculations of the eight wheel engine were made This shows in a general way the same characteristics of the average wear for the fifty three ten wheelers but is undoubtedly affected to a considerable extent by unknowable local conditions Here the front wheels, of course, correspond most nearly to the main wheels on the ten wheeler, and here, as there, the left main tire shows the most serious irregularity of wear

There is no doubt locomotive tires wear without slipping and there should be, and probably is, a portion of the irregular wear due to the pulverising or crushing action being greater under heavy than light loads The experiment made by removing all the over-balance in the counterbalance of C B & N engine 150, when the irregularities of wear in the main wheel were almost exactly duplicated in location, and to a remarkable degree in magnitude together with similar experiments attended by the same general results, and the fact that switch engine tires wear more evenly than even slow road engines, *lead us to believe that their irregularities of* wear are almost *wholly* caused by abrasion from slipping, and that the pulverizing of the steel from pressure alone is but of very minor importance

In conclusion, your Committee are of the opinion it is absolutely impossible to entirely avoid the irregular wear of locomotive tires in ordinary road service, and which is aggravated by sandy track, since these irregularities are due very largely to inequalities in the pressure of the driving wheels on the rail and the rotative force at different parts of each revolution, which are unavoidable in our present locomotive construction, and probably not entirely avoidable in any steam locomotive with reciprocating parts We also believe, however, that these irregularities of wear can be considerably reduced by *the careful design and operation of our present type of engine, and would* to this end recommend the observance of the following

1st Driving wheels should have ample weight for adhesion

2nd Main rods should be as long as is consistent in order to decrease the effect of angularity

3rd The weight of the reciprocating parts, and consequently the overbalance in the driving wheels, should be as light as possible

4th As small a proportion of the reciprocating parts should be balanced as is consistent with smooth working machinery and good riding conditions

5th. The driving boxes, shoes and wedges should be well maintained and kept properly adjusted.

6th. Have a careful and competent engineer in charge who will avoid slipping the drivers

W. H. LEWIS,
E. M. HERR,
J. H. McCONNELL,
Committee.

The Wear of Driving-wheels.

APPENDIX "A"

Location and Depth of Flat Spots in Driving-Wheel Tires. C, B & N R. R.

(Zero is located on the tire at its point of contact with the rail when the "right crank" is on the "forward center.")

CLASS "A" PASSENGER, 63 INCH CENTRES

	Back.		Front			Back		Front.	
	Location Deg	Depth Min	Location Deg	Depth Min		Location Deg	Depth Min	Location Deg	Depth Min
1 R . .	230	1/16	90	1/8	7 R .	230	1/8	90	3/16
1 L . .	130	3/32	110	7/32	7 L .	120	1/8	120	3/16
2 R . .	..	0	.	0	8 R .	130	1/32	90	1/4
2 L . .		0	110	1/8	8 L .	120	1/8	110	3/16
3 R . .	230	1/8	100	7/32	9 R .	200	1/16	140	1/16
3 L. . .	90	5/32	130	3/16	9 L .	140	3/32	120	3/16
4 R. . .	220	1/16	90	7/32	10 R .	130	1/64	140	1/16
4 L . .	90	1/8	110	3/16	10 L .	140	1/32	110	3/16
5 R . .	180	1/32	90	1/16	11 R	180	1/32	90	1/8
5 I . .	90	5/32	120	1/4	11 L. .	100	1/16	110	7/32
6 R. . .	180	1/16	90	3/32	12 R. .	220	1/16	90	3/32
6 L . .	120	3/32	110	3/16	12 L .	110	3/16	120	1/4

CLASS "A" FREIGHT, 57 INCH CENTRES.

	Back		Front			Back		Front	
	Location Deg	Depth Min	Location Deg	Depth Min		Location Deg	Depth. Min	Location Deg	Depth Min
50 R. . .	150	1/16	90	1/8	54 R .	160	5/32	80	5/32
50 L .	130	1/8	100	1/8	54 L .	140	3/32	100	3/16
51 R . .	150	1/8	200	1/8	55 R .	60	1/32		.
51 L . .	130	1/32	90	5/32	55 L .				
52 R .	160	1/8	200	5/32	56 R. . / L .	50	1/32	50	1/16
52 L .	150	3/32	100	3/16					
53 R . .	140	1/16	200	3/32	57 R .	150	1/16	110	1/8
53 L. . .	140	3/32	10	3/32	57 L. .	300	1/8	110	5/16

The Wear of Driving wheels

APPENDIX A —*continued*

CLASS A FREIGHT 57 INCH CENTRES.

		Back		Front				Back		Front	
		Location Deg	Depth Min	Location Deg	Depth Min			Location Deg	Depth Min	Location Deg	Depth Min
58	R					66	R	170	$\frac{3}{32}$	20	$\frac{3}{16}$
	L						L	140	$\frac{3}{32}$	100	$\frac{7}{32}$
59	R					67	R	160	$\frac{7}{32}$	120*	$\frac{5}{32}$
	L			110	$\frac{1}{16}$		L	140	$\frac{5}{32}$	105	$\frac{5}{16}$
60	R					68	R				
	L						L			140	$\frac{1}{8}$
61	R	50	$\frac{1}{8}$	60	$\frac{1}{8}$	69	R	150	$\frac{3}{32}$	80	$\frac{1}{8}$
	L						L	140	$\frac{1}{8}$	100	$\frac{5}{16}$
62	R			120	$\frac{3}{32}$	70	R	165	$\frac{1}{16}$	110	$\frac{3}{16}$
	L	130	$\frac{5}{32}$	100	$\frac{5}{16}$		L	140	$\frac{5}{32}$	90	$\frac{5}{16}$
63	R	160	$\frac{1}{8}$	80	$\frac{5}{32}$	71	R	300	$\frac{3}{32}$	190	$\frac{1}{8}$
	L	130	$\frac{3}{32}$	100	$\frac{1}{4}$		L	300	$\frac{1}{32}$	110	$\frac{7}{32}$
64	R	60	$\frac{1}{16}$	20	$\frac{3}{32}$	72	R	60	$\frac{3}{32}$	130	$\frac{1}{16}$
	L	130	$\frac{5}{32}$	100	$\frac{1}{4}$		L	150	$\frac{3}{32}$	100	$\frac{1}{4}$
65	R	160	$\frac{5}{32}$	90	$\frac{3}{16}$						
	L	130	$\frac{5}{32}$	100	$\frac{9}{32}$						

CLASS E SWITCH 44 INCH CENTRES.

		Back		Front				Back		Front	
		Location Deg	Depth Min	Location Deg	Depth Min			Location Deg	Depth Min	Location Deg	Depth Min
100	R	45	$\frac{1}{16}$	45	$\frac{1}{16}$	103	R	45	$\frac{3}{32}$		
	L	45	$\frac{3}{32}$	45	$\frac{1}{8}$		L			45	$\frac{1}{32}$
101	R					104	R				
	L						L				
102	R	10	$\frac{1}{8}$	20	$\frac{3}{32}$	105	R	45	$\frac{1}{32}$	20	$\frac{1}{32}$
	L	60	$\frac{1}{32}$	70	$\frac{1}{16}$		L	10	$\frac{1}{32}$	45	$\frac{1}{32}$

The Wear of Driving wheels.

APPENDIX "A"—*concluded*

CLASS B FREIGHT 56 INCH CENTRES

	Back		Middle		Front			Back		Middle		Front	
	Location Deg	Depth Min	Location Deg	Depth Min	Location Deg	Depth Min		Location Deg	Depth Min	Location Deg	Depth Min	Location Deg	Depth Min
150 R			110	$\frac{3}{16}$	220	$\frac{5}{32}$	158 R	60	$\frac{5}{32}$	60	$\frac{7}{32}$	300	$\frac{1}{16}$
150 L	130	$\frac{9}{32}$	90	$\frac{1}{4}$	310	$\frac{1}{8}$	158 L	70	$\frac{1}{4}$	90	$\frac{11}{32}$	330	$\frac{1}{8}$
151 R	170	$\frac{3}{32}$	120	$\frac{3}{16}$	220	$\frac{1}{8}$	159 R						
151 L	130	$\frac{1}{8}$	95	$\frac{7}{32}$	130	$\frac{1}{16}$	159 L						
152 R							160 R	160	$\frac{5}{32}$	120	$\frac{1}{8}$		
152 L							160 L	140	$\frac{5}{32}$	90	$\frac{5}{16}$	130	$\frac{1}{8}$
153 R	60	$\frac{1}{8}$	110	$\frac{1}{4}$	220	$\frac{1}{8}$	161 R	170	$\frac{3}{16}$	80	$\frac{1}{4}$	160	$\frac{3}{16}$
153 L	65	$\frac{3}{16}$	90	$\frac{5}{16}$	130	$\frac{3}{16}$	161 L	140	$\frac{9}{32}$	90	$\frac{1}{4}$	130	$\frac{1}{8}$
154 R	150	$\frac{1}{8}$	115	$\frac{5}{16}$	240	[illegible]	162 R						
154 L	130	$\frac{5}{16}$	100	$\frac{6}{16}$	130	$\frac{3}{32}$	162 L						
155 R	150	$\frac{5}{32}$	120	$\frac{3}{16}$	220	$\frac{1}{8}$	163 R	160	$\frac{1}{4}$	80	$\frac{11}{32}$	230	$\frac{1}{8}$
155 L	70	$\frac{7}{32}$	100	$\frac{5}{16}$	220	$\frac{9}{32}$	163 L	150	$\frac{1}{4}$	90	$\frac{11}{32}$	130	$\frac{5}{32}$
156 R							164 R	150	$\frac{7}{32}$	110	$\frac{3}{16}$	220	$\frac{5}{32}$
156 L							164 L	140	$\frac{1}{8}$	90	$\frac{11}{32}$	310	$\frac{5}{32}$
157 R													
157 L													

The Wear of Driving wheels.

APPENDIX "B"

COMPARATIVE PERFORMANCE OF DRIVING-WHEEL TIRES.

Eng. No.	Type.	Size of cylinders	Weight of engine	Weight on drivers.	Diam of driving wheels	Weight of engine and tender	Steam pressure	Card time of train speed.	Tire	Thickness	Applied.	Removed.	Service	Turned off	Miles to $\frac{1}{16}$	Mileage in 6 years	Total mileage of tire.	REMARKS.
73	8-wh.	16 x 24 in	69 500 lbs	42 800 lbs	69 in.	121,473 lbs	140 lbs.	22 miles	Butcher	2$\frac{9}{16}$ in	May, 1875	Aug., 1881	6 years	$\frac{11}{16}$	15 297	198 865	245 200	
74	"	"	"	"	"	"	"	"	Nashua.	2$\frac{11}{16}$ in	Mch., 1874	Aug., 1882.	"	$\frac{11}{16}$	14 955	284,146	314 941	
75	"	"	"	"	"	"	"	"	"	2$\frac{11}{16}$ in	Nov., 1878	Apl., 1884.	"	$\frac{11}{16}$	12,356	197 700	240 904	
76	"	"	"	"	"	"	"	"	Krupp.	2$\frac{11}{16}$ in	Feb., 1874.	May, 1881	7 years	$\frac{11}{16}$	13,341	213 456	265,796	
77	"	"	"	"	"	"	"	"	Butcher	2$\frac{11}{16}$ in	July, 1873.	Oct., 1881	8 years	$\frac{11}{16}$	18,151	254,110	314,480	Average miles to $\frac{1}{16}$ wear of tire, 14 722.
									Above Engines Rebuilt.		Larger Boiler							
73	8-wh.	17 x 24 in	76,100 lbs	47,000 lbs	69 in	141,333 lbs.	150 lbs	25 miles	Midvale.	2$\frac{11}{16}$ in	Aug., 1881	Jan., 1887.	About 6 yrs.	$\frac{11}{16}$	10,603	233 266	272 319	
74	"	"	"	"	"	"	"	"	"	2$\frac{11}{16}$ in.	Aug., 1882	June, 1890.	" 8 "	$\frac{11}{16}$	9,305	178,517	286,343	
75	"	"	"	"	"	"	"	"	Union	2$\frac{11}{16}$ in	Apl., 1884	Jan., 1890	" 6 "	$\frac{11}{16}$	9,149	192,120	213,053	
76	"	"	"	"	"	"	"	"	Krupp	2$\frac{11}{16}$ in	May, 1881	Oct., 1888.	" 7 "	$\frac{11}{16}$	14,078	253 416	237 993	
77	"	"	"	"	"	"	"	"	Midvale	2$\frac{11}{16}$ in	Oct., 1881	Mch., 1890.	" 8 "	$\frac{11}{16}$	12,399	285,185	329,010	Average miles to $\frac{1}{16}$ wear of tire, 11,092
813	"	18 x 24 in.	93,500 lbs	59,600 lbs	"	155 230 lbs.	160 lbs	33 miles	Krupp	3$\frac{3}{8}$ in	Aug., 1888	Mch., 1894	"	$\frac{11}{16}$	10,216	163 448	Not worn out.	
814	"	"	101,330 lbs	67 300 lbs	"	208 563 lbs.	"	"	"	3$\frac{7}{16}$ in.	Apl., 1890.	Nov., 1893	" "	$\frac{11}{16}$	9 673	174 122	"	
815	"	"	93,300 lbs	59 600 lbs	"	155 230 lbs.	"	"	"	3$\frac{9}{16}$ in	June, 1891	Jan., 1894		$\frac{11}{16}$	9 537	123 978	"	
816	"	"	97 600 lbs	63,000 lbs	"	204,833 lbs	"	"	Standard.	3$\frac{11}{16}$ in	July, 1887	Apl., 1893	" "	$\frac{11}{16}$	11 431	274,353	"	
817	"	18 x 26 in	100 000 lbs	64 000 lbs.	"	207,333 lbs.	"	"	"	3$\frac{11}{16}$ in	Oct., 1887	July, 1893	" "	$\frac{11}{16}$	10,212	296,138	"	Average miles to $\frac{1}{16}$ wear of tire, 10,320.
935	"	"	109 800 lbs.	73 400 lbs	"	216,433 lbs	180 lbs	"	Midvale.	3$\frac{7}{16}$ in	May, 1892	Feb., 1894	"	$\frac{7}{16}$	13 143	92,000	"	
837	"	"	"	"	"	"	"	"	"	3$\frac{9}{16}$ in.	June 1892	Dec., 1893	" "	$\frac{11}{16}$	6 911	76,020	"	
838	"	"	"	"	"	"	"	"	"	3$\frac{9}{16}$ in.	May, 1893	Apl., 1894	" "	$\frac{9}{16}$	8 935	80 419	"	
839	"	"	"	"	"	"	"	"	"	3$\frac{7}{16}$ in	Oct., 1892	Dec., 1893	" "	$\frac{6}{16}$	8 595	51,590	"	
840	"	"	"	"	"	"	"	"	"	3$\frac{9}{16}$ in	Aug., 1892	Dec., 1893	"	$\frac{8}{16}$	8 309	66,468	"	Average miles to $\frac{1}{16}$ wear of tire, 8 933
845	"	18 x 24 in	97 600 lbs.	63 000 lbs.	"	204 833 lbs.	"	41 miles.	Standard.	3$\frac{11}{16}$ in	Apl., 1893	May, 1894	" "	$\frac{4}{16}$	9,535	38,143	"	Fast mail
849	"	18 x 26 in.	100 000 lbs.	64,000 lbs.	"	207 333 lbs	"	"	"	3$\frac{11}{16}$ in	July, 1893.	May, 1894	"	$\frac{4}{16}$	8 292	33,168	"	Average miles to $\frac{1}{16}$ wear of tire, 8 914.
844	"	"	107,000 lbs.	69 300 lbs.	"	214 233 lbs.	"	"	Midvale.	3$\frac{9}{16}$ in	May, 1893.	June, 1894	" "	$\frac{5}{16}$	6,358	31 789	"	Fast mail
843	"	"	"	"	"	"	"	"	"	3$\frac{9}{16}$ in.	July, 1893.	Feb., 1894	" "	$\frac{4}{16}$	7,167	28 669	"	Average miles to $\frac{1}{16}$ wear of tire, 6 717

APPENDIX "A."—*concluded*

CLASS "B FREIGHT 56 INCH CENTRES

	Back		Middle		Front			Back		Middle		Front	
	Locat on Deg	Depth M n	Location Deg	Depth M n	Locat on Deg	Depth M n		Locat on Deg.	Depth M n	Location Deg	Depth M n	Locat on Deg	Depth M n
150 R			110	3/16	220	5/32	158 R.	60	5/32	60	5/32	300	1/16
150 L.	130	5/32	90	1/4	310	1/8	158 L.	70	1/4	90	11/32	330	1/8
151 R	170	3/32	120	3/16	220	1/8	159 R						
151 L.	130	1/8	95	7/32	130	1/16	159 L						
152 R							160 R	160	5/32	120	1/8		
152 L.							160 L.	140	5/32	90	5/16	130	1/8
153 R	60	1/8	110	1/4	220	1/8	161 R.	170	3/16	80	1/4	160	3/16
153 L	65	3/16	90	5/16	130	3/16	161 L	140	3/32	90	1/4	130	1/8
154 R	150	1/8	115	3/16	240	5/32	162 R						
154 L	130	3/32	100	5/32	150	3/32	162 L.						
155 R	150	5/32	120	3/32	220	1/8	163 R	160	1/4	80	11/32	230	1/4
155 L	70	7/32	100	5/16	220	5/32	163 L	150	1/4	90	11/32	130	5/32
156 R							164 R	150	5/32	110	3/16	220	1/16
156 L							164 L.	140	1/8	90	11/32	310	5/32
157 R													
157 L													

The Wear of Driving wheels.

APPENDIX "B"

COMPARATIVE PERFORMANCE OF DRIVING-WHEEL TIRES.

Eng. No.	Type	Size of cylinders	Weight of engine	Weight on drivers.	Diam of driving wheels	Weight of engine and tender	Steam pressure	Card time of train speed.	Tire	Thickness	Applied	Removed.	Service	Turned off	Miles to $\frac{1}{16}$	Mileage in 6 years	Total mileage of tire	REMARKS
73	8-wh.	15 x 24 in	69 500 lbs	42 800 lbs	69 in	121,473 lbs.	140 lbs.	22 miles	Butcher	2$\frac{9}{16}$ in	May, 1875	Aug., 1881	6 years	$\frac{11}{16}$	15 297	198 865	245,200	
74	"	"	"	"	"	"	"	"	Nashua.	2$\frac{11}{16}$ in	Mch., 1876	Aug., 1882	"	$\frac{11}{16}$	14 955	184 146	314,945	
75	"	"	"	"	"	"	"	"	"	2$\frac{11}{16}$ in	Nov., 1878	Apl., 1884.	"	$\frac{11}{16}$	12,356	197 700	240 904	
76	"	"	"	"	"	"	"	"	Krupp	2$\frac{13}{16}$ in	Feb., 1874.	May, 1881	7 years	$\frac{11}{16}$	13 341	213 456	265 796	
77	"	"	"	"	"	"	"	"	Butcher	2$\frac{11}{16}$ in	July, 1873	Oct., 1881	8 years	$\frac{11}{16}$	18,151	254,110	314,480	Average miles to $\frac{1}{16}$ wear of tire, 14 722.
									Above Engines Rebuilt.		Larger Boiler							
73	8-wh.	17 x 24 in	76,100 lbs.	47,000 lbs.	69 in.	141,333 lbs	150 lbs.	25 miles	Midvale	2$\frac{11}{16}$ in.	Aug., 1881	Jan., 1887.	About 6 yrs	$\frac{11}{16}$	10,603	233,266	272 319	
74	"	"	"	"	"	"	"	"	"	2$\frac{11}{16}$ in	Aug., 1882	June, 1890	" 8 "	$\frac{11}{16}$	9 305	178,517	286 343	
75	"	"	"	"	"	"	"	"	Union	2$\frac{11}{16}$ in	Apl., 1884	Jan., 1890	" 6 "	$\frac{11}{16}$	9,149	192,120	212,053	
76	"	"	"	"	"	"	"	"	Krupp	2$\frac{13}{16}$ in	May, 1881	Oct., 1888	" 7 "	$\frac{11}{16}$	14,078	253 416	337,992	
77	"	"	"	"	"	"	"	"	Midvale	2$\frac{11}{16}$ in	Oct., 1881	Mch., 1890.	" 8 "	$\frac{11}{16}$	12 399	285,185	329,010	Average miles to $\frac{1}{16}$ wear of tire, 11,092
813	"	18 x 24 in	93,500 lbs	59 600 lbs	"	155,230 lbs.	160 lbs	33 miles	Krupp	3$\frac{3}{8}$ in	Aug., 1888	Mch., 1894	... ..	$\frac{11}{16}$	10 216	163,448	Not worn out	
824	"	"	101,330 lbs.	62 300 lbs	"	208 563 lbs	"	"	"	3$\frac{7}{16}$ in	Apl., 1890	Nov., 1893		$\frac{11}{16}$	9 673	174,121	"	
825	"	"	93,500 lbs	59 600 lbs	"	155 230 lbs.	"	"	"	3$\frac{7}{16}$ in	June, 1891	Jan., 1894		$\frac{11}{16}$	9 537	123 978	"	
448	"	"	97 600 lbs	63 000 lbs	"	204 833 lbs.	"	"	Standard	3$\frac{11}{16}$ in	July, 1887	Apl., 1893	.. ..	$\frac{11}{16}$	11 431	274,353	"	
827	"	18 x 26 in	100 000 lbs	64 000 lbs.	"	207,233 lbs	"	"	"	3$\frac{11}{16}$ in	Oct., 1887	July, 1893.	....	$\frac{11}{16}$	10,212	296,138	"	Average miles to $\frac{1}{16}$ wear of tire, 10 320.
833	"	"	109 300 lbs	73,400 lbs	"	216,433 lbs	180 lbs	"	Midvale.	3$\frac{7}{16}$ in	May, 1892	Feb., 1894	....	$\frac{1}{16}$	13,143	92 000	"	
837	"	"	"	"	"	"	"	"	"	3$\frac{7}{16}$ in.	June, 1892	Dec., 1893	....	$\frac{1}{16}$	6 911	76,020	"	
838	"	"	"	"	"	"	"	"	"	3$\frac{7}{16}$ in	May, 1892	Apl., 1894.	....	$\frac{1}{16}$	8 935	80 419	"	
839	"	"	"	"	"	"	"	"	"	3$\frac{7}{16}$ in	Oct., 1892	Dec., 1893	.. ...	$\frac{1}{16}$	8,598	51,590	"	
840	"	"	"	"	"	"	"	"	"	3$\frac{7}{16}$ in	Aug., 1892	Dec., 1893	....	$\frac{1}{16}$	8 309	66,468	"	Average miles to $\frac{1}{16}$ wear of tire, 8 938
825	"	18 x 24 in.	97 600 lbs.	63 000 lbs.	"	204,833 lbs.	"	42 miles.	Standard.	3$\frac{11}{16}$ in	Apl., 1893.	May, 1894	.. ..	$\frac{1}{16}$	9 535	38,143	"	Fast mail
829	"	18 x 26 in.	100,000 lbs.	64 000 lbs	"	207 233 lbs	"	"	"	3$\frac{11}{16}$ in.	July, 1893.	May, 1894	... ...	$\frac{1}{16}$	8 292	33 168	"	Average miles to $\frac{1}{16}$ wear of tire 8 914.
844	"	"	109,000 lbs.	69 300 lbs	"	214 233 lbs.	"	"	Midvale.	3$\frac{7}{16}$ in	May, 1893	June, 1894		$\frac{1}{16}$	6 358	31 788	"	Fast mail
845	"	"	"	"	"	"	"	"	"	3$\frac{7}{16}$ in	July, 1893.	Feb., 1894	.. ..	$\frac{1}{16}$	7,367	28 669	"	Average miles to $\frac{1}{16}$ wear of tire, 6 717

Discussion on Wear of Driving-Wheel Tires.

MR. J. H. MCCONNELL—In order to determine what effect high speed, increased weight and increased boiler pressure had on the wear of the tire, I took the records of some of our locomotives for the past twenty years, starting in with five 16 inch cylinder, 69-inch driving wheel, carrying 140 pounds pressure and making a time-card speed of 22 miles an hour After those engines were worn out they were rebuilt with a 17 inch cylinder, carried 150 pounds of steam and their speed was increased to 25 miles an hour We afterwards built some 18-inch cylinders, and the speed was increased to 33 miles an hour and our steam pressure to 160 pounds We have some engines now with 180 pounds, and one train with a time card speed of 41 miles an hour The 16 inch cylinder with 140 pounds pressure had about 38,000 pounds weight on the driving wheels and the average wear on the tires of those engines was 14,722 miles to $\frac{1}{16}$ When the engines were rebuilt, the steam pressure increased to 150 pounds and the speed to 25 miles an hour, the tire wear decreased to 11,092 to $\frac{1}{16}$ With the 18 inch cylinders, weighing about 100 000 pounds with 73 000 pounds weight on the driving wheels and 160 pounds of steam, we got 10,320 miles to the $\frac{1}{16}$ With those same engines, when we increased the speed to 33 miles an hour and 180 pounds of steam, we got 8 938 miles to the $\frac{1}{16}$ With the engines on our fast mail, where the time is scheduled at 41 miles an hour, these engines weighing 171 000 pounds and having 69 000 pounds weight on the driving wheels with 180 pounds of steam, the average mileage of the tire was 6,717 miles to the $\frac{1}{16}$ That shows the effect of high speed, high steam pressure, and increased weight on the driving wheels.

MR J O PATTEE—I would like to ask Mr McConnell if the tire was of the same manufacture—the same grade of tire?

MR J H MCCONNELL—No, sir they were a variety of tires On the 16 inch cylinder 22 miles an hour, one engine had Worcester tire, another had Nashua Iron Company's steel tire, the other had Krupp tire, and the fifth one had Butcher tire On the 17 inch cylinders there were Union steel tire, Krupp tire and Midvale tire. The average of the first five engines was 14 000 miles to the $\frac{1}{16}$ the second five, 11,000 miles to the $\frac{1}{16}$ The first engine—Engine 73—the light engine with Butcher tire, averaged 15 000 miles to the $\frac{1}{16}$ The second engine with the Nashua Iron Company's steel tire, averaged 14 955 miles to the $\frac{1}{16}$ The third one had the Nashua Company's steel tire and averaged 12 356 The Midvale tire averaged 13 341 The Butcher tire averaged 18,851 miles

MR PATTEE—When you changed the condition of the engine did you change the tire?

MR MCCONNELL—We followed this tire as it was worn out, and we used the same size driving wheel all the way through The diameter of the driving wheel was the same

MR GEORGE GIBBS—I would like to ask if the Committee have been able to give us any figures from replies to circulars, or otherwise, of the probable effect of increased weight on our driving wheels That is one of the most important points of the subject as I understand it We have been raising the weight on the drivers of the eight-wheel engine from 32 000 up to 42,000 per pair, and the effect of the increased weight on the rail is quite an important point

MR EDWIN H HERR—I would say in answer to Mr. Gibbs' question that the Committee have no further data except that just read by Mr McConnell, and which is included in the Committee's report That bears directly upon the question Mr Gibbs has raised, and shows that the wear is very much greater as the weight is increased But it also shows that even on engines having less weight than some others, where the speed is

higher the wear is increased, that is those having the highest speed, even with the lower wheel weight, show a greater tire wear than those with the heavier wheels and the slower speeds

Mr D L. BARNES—There is a point in these diagrams that bears directly on that If you will notice on the diagrams on the wall, there is a point in the revolution of the driver where there is *double the weight* and a *very high speed.* Now, if these conditions are to give a maximum wear we ought to find it on the tire wear diagram We turn to the tire-wear diagram on the other wall, and at 90 degrees, which is the point of the greatest weight, we find the minimum wear Now, I do not understand that this Committee has established any relation whatsoever between the balancing of the locomotive and the wear of the tire I have examined a great many diagrams, and have been surprised to find that some engines wear their tires almost uniformly, while others in the same class and the same service do not wear uniformly I am led, therefore, to allot the cause of rail wear—the irregularity of it—to the engineer who handles the engine It is interesting to see that Mr Herr, in his very complete and valuable calculations about this matter has found no reason for "imperceptible slip" Some tests have recently been made near Pittsburgh on a railroad which showed over long distances that the revolutions of the drivers multiplied by the circumference of the drivers amounted to almost exactly the length of the track In regard to Mr McConnell's data we have to remember that there are a great many and varying conditions He has not changed the one condition and made a set of tests, but he has changed a great many conditions

Mr HERR—In regard to the point raised by Mr Barnes, I wish to say that in reading the report as I have, by abstract, there are a good many points that are not clearly brought out Perhaps I should explain that Mr Barnes is entirely correct, and that the Committee show in their report if it is read completely that the wear is not due principally to the increase in pressure due to the overbalancing but it is due most particularly to the slipping of the engine, and most largely to the slipping that occurs when the engine is just starting, and although the sixth point—having a careful engineer at the throttle—is put last in the Committee's report, it seems to me at least that it is one of the most important points to be observed in reducing the irregular wear of tires It will be seen that the slip that occurs at speed, from this diagram, when the centrifugal force of the counterbalance comes into action and only then, does cause an increase in wear as represented in this part of the diagram It is more noticeable here, these spots are elongated out where the centrifugal force of the counterbalance comes into effect most severely in this portion of the diagram here But the principal cause of spotting is not the overbalancing, but it is the slight slip that occurs at starting and at other times This portion I failed to say anything about in reading the report, although it is very interesting, and I am glad that Mr Barnes called my attention to it It is difficult for you to see it, but when it is printed you can look at it at your leisure This is a diagram of four turnings of the tires of Engine 150 on the Chicago Burlington and Northern road taken by Mr Lewis The first turning was taken with the full amount of the counterbalance, just as the engine was balanced by the makers, the full amount of the reciprocating parts being balanced in the wheels He then removed all this excess balance, and balanced the wheels only by the revolving parts and the next line shows the result, shows the wear after the entire amount of the overbalance had been removed and shows the spot noticeable in the main wheels, coming in almost identically the same positions as they came with the excess counterbalance In the forward and back wheels it is not so noticeable and should not be because the counterbalance has more effect on the front and back wheels, as I explained, than it has on the others But the point raised is entirely a correct one, and the Committee's report will bear that out

VARIATION IN LOAD ON LOCOMOTIVE DRIVING-WHEELS WHEN RUNNING UNDER STEAM

In the preceding paper two considerations which affect the variation in load are neglected—

(1) The fact that the force in the connecting rod acts, in outside cylinder engines, in a plane outside the wheels therefore with a certain leverage, so that the vertical force acting in the plane of the wheel is greater than that acting in the plane of the cylinder This does not affect the total load on *a pair* of wheels, as whatever this leverage adds to the wheel on one side it takes off from that on the other it, therefore, does not materially affect the question of slip, but it increases the maximum pressure of the wheel on the rail, and the load on girders, particularly when these are placed immediately under the rails

(2) The fact that the same vertical force which adds to the weight on the wheel at the crank pin is acting upwards on the guides and lifting the front end of the frame, thereby decreasing the load not only on the leading bogie but on all the other wheels except perhaps the trailing wheels The exact ratio in which this decrease takes place in the different wheels is somewhat difficult to determine, but it is reasonable to assume that it is proportional to the distance of each wheel from the trailing wheel multiplied by the elasticity of its spring It is also reasonable to assume that the elasticity of each spring is proportional to the load on it, that is, that a spring which carries 5 tons would *deflect the same under 5 tons as one carrying 3 tons would deflect under 3 tons* or in the ratio of 3 to 5 for equal loads It has been assumed in the previous paper that all that is added to the load through the crank pin is taken off the bogie only The types of engine dealt with have longer connecting rods in proportion to the stroke than the majority of engines in India they also have horizontal cylinders In the passenger engines the connecting rods are over 7 times the radius of the crank and in the six coupled engines over 9 times so that the greatest inclination of the connecting rod is only about 1 in 7 and 1 in 9 respectively, while in the State Railway 'L class the rod is only about 6¼ times the radius of crank with a cylinder inclined 1 in 8, so that the greatest inclination of the rod is about 1 in 3½ hence the variation of pressure due to this cause is about 2½ times as great as in the six coupled American engine In the metre gauge 'F' class the rod is about 6 times the radius of the crank the cylinder also being inclined 1 in 8 and this together with its comparatively short wheel base makes the variation even greater in proportion than in the broad gauge "L class

If we take the 'L class engine and assume the force on one piston to be 20 tons, which corresponds to a cylinder pressure of slightly under 140 lbs per square inch, the downward force on the crank pin will reach a maximum of 5 75 tons which will be increased by the leverage by about 15 per cent making about 6 61 tons in the plane of the wheel There will be an upward force of 2 5 tons at the cylinder and 3 25 tons at the guides, making as before a total of 5 75 tons in the plane of the cylinder, increased to 6 61

tons in the plane of the wheels, which is distributed over the springs approximately as follows —

Taken off bogie	3·03
„ front coupled wheels	2·27
„ driving wheel	1·31
TOTAL	6·61

The net result is that 6·61 − 1·31 = 5·3 tons are added to the weight on one driving wheel, when the increase on the right side is a maximum, there is practically no alteration on the left side due to the obliquity of the left rod, but there will be a lift of about 0·86 tons due to the leverage on the crank pin and an increase in load of 0·2 tons on the spring due to the leverage on the frame, making a net lift of 0·66 ton on the left wheel The actual pressure of each driving wheel on the rail when the engine is working in full steam at slow speed will, therefore, vary from 5·3 tons above to 0·66 ton below the normal weight. If we take the normal load on the wheel to be 6½ tons, which is about that in the heaviest "L" engine, this represents an increase of over 80 per cent, while if we take the normal load at 7½ tons, the maximum permissible, the increase is over 70 per cent.

If the cylinder were horizontal, instead of inclined, the maximum downward pressure on the crank pin, and upward pressure on the guides would be 3·125 tons, which would be increased by the leverage to 3·59 tons in the plane of the wheels

The corresponding lift would be—

Taken off bogie	1·63 tons
„ off front coupled wheel	1·25 „
„ off driving wheel	0·71 „

The net result being 2·88 tons added, or little more than half the increase produced by the inclined cylinder.

In the case of the metre gauge "F" class, if we take the force on one piston as 12 tons, corresponding to slightly under 140 lbs per square inch, the downward force on the crank pin will reach a maximum of 3·54 tons, and as the overhang is far greater in proportion to the gauge than in the case of the "L" class, the leverage adds about 30 per cent, making 4·6 tons in the plane of the wheel, the upward forces acting in the plane of the wheels are 1·95 at the cylinder and 2·65 at the guides, which reduce the loads on the springs by—

on the leading wheel	3·2 tons,
„ driving wheel	1·4 „

making a net increase on the driving wheel of 3·2 tons, the net lift due to the leverage on the wheel on the other side being 0·96 tons The total pressure of each driving wheel on the rail, when the engine is working in full steam at slow speed varies from 3·2 tons above to 0·96 tons below the normal of 3·9 tons the increase being over 82 per cent If the driving wheel carried the maximum permissible of 4 tons, the increase would be 80 per cent.

If the cylinders were horizontal instead of inclined, the maximum pressure downwards on the crank pin, and upwards on the guides would be 2·04 tons, increased by the leverage to 2·65 tons in the plane of the wheels, the corresponding lift on the springs

would be—

on the leading wheel	1 82 tons,
,, driving wheel	0 83 ,,

the net result being 1 82 tons added, or not much more than half that produced by the inclined cylinder, if the connecting rod were a little longer, the amount would be reduced to half

If the cylinders were inside instead of outside, the leverage would reduce instead of increasing the variation in pressure, as this would be divided between the two driving wheels

It must be remembered that though the amount added by the downward pressure on the crank pin can be accurately calculated, that taken off by the upward pressure on the guides and the inclined cylinder raising the frame slightly on the springs can only be given approximately, it is clear that it cannot take any of the weight off the springs unless it actually lifts the frame, and the maximum upward force usually acts for only a comparatively small period of each revolution, so that it is probable it has not time to complete the lift, and the frame probably oscillates only slightly up and down from the position corresponding to the *average* lifting force exerted during a whole revolution, so that the lift on the springs of the driving wheels will always be less than given in the above figures, and consequently the increase in their pressure on the rails will be more

If the experiment were tried on an engine not in steam, which could be done by taking down the connecting rod, blocking up the piston in the proper position, and replacing the connecting rod by a jack exerting the proper pressure on the cross head and crank pin, the increase of pressure on the driving wheels could be measured, but the result would not be of much value as the conditions do not accurately represent those in ordinary running

September 1895 F W D

EXPRESS LOCOMOTIVES

Extract from the report by John H F Aspinall, Chief Mechanical Engineer, L and Y. Railway, to the International Railway Congress, London, 1895

The report is divided into the following heads —

(1) Type of engine most suitable for high speeds (2) The use of high pressure and application of the compound principle (3) Improvements in distribution and balanced slide valves (4) Engine building regarded from the point of view of diminishing the strains on the permanent way (5) The effect from this latter point of view of the compound principle (6) Description of individual engines

(1) Type of engine most suitable for high speeds—When originally asked to write a paper for the International Congress of 1895, the author was requested to take up the subject No VI, on Express Locomotives," the chief headings of which are given above It has unfortunately, however, been quite impossible owing to the very limited time given to follow out this programme in its entirety, and practically, the following data represent the result of the replies which the author has been able to obtain from Engineers on the Continent, in Great Britain, the United States, and the Colonies, which deal almost entirely with the leading dimensions of the engines which they use for express traffic, and do not go beyond the mere facts as to the construction of such engines as they use to-day The paper will not therefore deal with the subjects mentioned in the original programme except where information has been given which can be included within it The author considers that by presenting the diagrams and dimensions of the locomotives in use on the many railways which are mentioned in the papers, he at once gives in a practical form the opinions of the leading Engineers as to the best practice, and the type of engine most suitable for high speeds which depends almost entirely upon the nature of the road over which it has to perform its duty. If the road is of an easy and level nature, and the loads of the trains to be hauled comparatively light, engines with single driving wheels are found to be most successful owing to the fact that the adhesive power is not so important a factor, and the absence of coupling rods enables the engine to run with greater freedom

On the other hand, when the road is heavy and of a sinuous nature, engines with coupled wheels having plenty of adhesion and tractive force, are found to give the best results

The most important part of a high speed locomotive is its boiler capacity, for as the speed increases so will the demand for steam the distance travelled in a given time being greater, and the train resistance augmented, consequently larger cylinders are required, and, therefore, steam must be more rapidly provided

The engine which finds most favour in Great Britain and America is the four wheels coupled tyre, the leading end being carried on a four wheel bogie The bogie not only enables the engine to pass round curves easily, but also, owing to the longer wheel base, distributes sufficient weight at the greatest distance from the driving wheel This tends to solidify the road and it is then in the best position to support the heavier weight carried by the driving and trailing wheels In this type the first thing to be considered

would be—

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is the rigid wheel base which should be as short as possible, for if this is too long, accidents may arise through broken coupling rods, caused by the severe strains to which they are subjected.

The maximum capacity of the locomotive boiler is nearly reached In America and on the Continent, engines with much larger boilers can be constructed than in England, owing to the greater limits of the bridges and platforms in the respective countries. The rigid wheel base practically determines the size of the fire box, because longitudinally it has to be placed between the axles, and transversely between the main frames, the latter being placed at present as far apart as the wheels will permit

In America fire boxes have been made much larger by placing them above the frames and pitching the boilers very high, a practice which in this country cannot be accomplished on account of our bridges This method has the additional advantage of enabling the wheel base to be shortened The question as to what may in future be done in the way of an increase of speed on railways is one which has received a great deal of attention from many railway authorities, and though, perhaps, the fastest running that we have heard of as yet has been made upon the New York Central Railroad in America, yet it is a question whether such high rates of speed can be maintained upon the more crowded railways of England, upon which the average speeds are already very much faster than are found on the Continental Railways On this subject of the increase in speed and the difficulties connected therewith, three papers appeared in the March number of the 'Scribner's Magazine" in 1892, by well known American authorities, in one of which Mr. M N. Forney pointed out that fast running is largely a question of steam production, and that the limits placed on the weight and dimensions of a locomotive were difficult to get over, while the generally accepted rules of resistance to trains on a level track were such as to put almost insuperable difficulties in the way of any great increase of speed

Mr Theo N Ely, of the Pennsylvania Railroad, followed with a short paper, in which he also pointed out that the "measure of the speed and capacity of a locomotive rests in the fire box," and then went on to say with regard to the possibility of attaining an average speed of 100 miles an hour, that first of all we must know how soon after receiving warning of danger, a train running a mile in 36 seconds can be stopped It is estimated under the most favourable conditions that this train mentioned above, could not be brought to a stop in less than 2,500 ft, but allowing for the worst conditions, would it be too much to ask that the engineman receives his warning, at least three quarters of a mile before he must halt! It is fair, therefore, we think, to rest the burden upon the transportation shoulders and predict that with it, and it alone lies the practical limit of the speed of railway trains drawn by steam locomotives. Mr. Ely has undoubtedly hit upon the most serious difficulty when he thus points out that a very clear track is needed for such great increase of speed but Mr H Walter Webb in the third paper, follows on and tells us, that having acquired a clear track for a certain train, they actually ran from New York to East Buffalo, a distance of 436 3 miles in 439 5 minutes, and dealing only with the higher speeds attained, he states that 151 miles were run at a rate varying from sixty five to seventy miles per hour, and thirty seven miles were run at a rate varying from seventy to seventy eight miles per hour

It was for this road that the celebrated No 999 engine, designed by Mr William Buchanan was built, and speeds much in excess of the maximum named have been actually attained in practice with this engine. The "Engineer," London, for March 7th, 1890, records a speed of 90 miles per hour, which was attained on the level with a compound engine built by the North Eastern Railway Company, hauling a train of eighteen carriages, the gross weight of which was 310 tons Another American writer,

however, Mr David L Barnes in the June number of the Engineering Magazine, 1894 speaking of very fast running says that "High maximum speed is spectacular, but no practical, while a high average speed is a real necessity, and can be obtained." He states in a similar manner to the authors previously mentioned the absolute necessity for larger boiler capacity than we at present possess and further, that "High average speed on heavy grades is impossible within the limits of steam locomotive construction," by the fact that a grade of 1 per cent demands about 1 500 additional horse power at 100 miles per hour, and 900 at 60 miles an hour This shows how a light grade may increase considerably the demand on the locomotive boiler at high speed M. Du Bousquet the President of the French Society of Civil Engineers, pointed out in March 1894, that speeds of 75 miles per hour are attained daily on down grades by express trains in their ordinary running, thus showing that high speeds are not dangerous. The reason why such speeds are not maintained on the level is, he states, because the engines are not sufficiently powerful 'The draw bar pull which would give a speed of 75 miles per hour on a down grade of 1 in 200, would only give a speed of $57\frac{1}{2}$ miles per hour on the level and $31\frac{1}{4}$ miles per hour on an up grade of 1 in 200 To increase the average speed by a small amount the power of the engine must be greater in proportion thus if 322 horse power is sufficient to haul a train at [illegible] per hour up an incline of 1 in 200, 2 960 horse power will be required to draw the same train up the grade at a speed of 125 miles per hour In dealing with [illegible] speeds the weight of the engine per horse power generated is of importance, as [illegible] is always a limit of speed beyond which the engine cannot draw itself, let alone [illegible] as well At present, French express locomotives weigh about 158 lbs, per [illegible] horse power when exerting their maximum effort By an application of these [illegible] we find that to draw a train of 100 tons at a speed of 75 miles per hour up an [illegible] of 1 in 200 an engine would have to weigh 130 tons and generate 1,810 horse power, If the speed was increased to 87 miles per hour on a similar incline the engine would [illegible] to weigh 468 tons and generate 6,532 horse power'

This consideration of high speeds reminds the author that Mr D. L Barnes, in paper already referred to, showed the engine and train resistance to be [illegible] generally supposed The formula of Mr D K Clark for engine, tender, and [illegible] sistance, also train resistance only, as well as M Du Bousquet's figures [illegible] from actual experiments by the aid of a dynamometer fixed on the coupling [illegible] and train, agree very closely, whereas that of Mr Barnes is considerably [illegible] total resistance In each case the resistance due to grades has been neglected

If Mr D K Clark's formula $\frac{V^2}{171}+8$ for engine tender and train resist[illegible] to the American "Empire State Express" at 100 miles per hour, the total res[illegible] *66 5 x 283 tons = 18,800 lbs but as the tractive power of the engine* [illegible] 13 399 lbs , and as it probably does not develop more than 1,200 to [illegible] its maximum effort, it points to the fact that Clark's and Du Bousquet's [illegible] high, but at the same time the author is of opinion that those [illegible] The difficulty of making up any time lost by a train which is booked [illegible] is very great indeed, to take an extreme case, if the average speed [illegible] and this be increased to 70 one minute will be made up in every [illegible] example, if a train running at 65 miles per hour has lost a min[illegible] miles at 70 miles per hour in order to make up that minute, [illegible] a great length of line must be run over in order to make up [illegible] time as one minute

Having thus far considered the limitations fixed by speed [illegible] these difficulties have been surmounted, the most serious [illegible]

account of the existing construction and dimensions of stations, bridges and tunnels Even at the present moment these structures on English railways would not enable some of the American or Continental engines to pass A diagram of the outline of English rolling stock and minimum structure in tunnels placed upon those of American and Continental rolling stock shows this at a glance, it will be observed that both the American and Continental rolling stock would not pass through

(2) *The use of high pressure and application of the compound principle*—The compound principle as applied to the locomotive may now be taken as having passed the experimental stage, consequently the author will not presume to lay before the members of this Congress its primary objects which are now so well known Its application has received much attention in this country and even more so abroad. The systems now generally adopted are known by their exponents, *viz*, Mallet, Worsdell and Von Borries Webb and Vauclain, each having two, three and four cylinders respectively, the latter being mostly used in the United States, and a description of each will be found in the statement relating to the various railway companies See Plates Nos LXIX to LXXIV.

A system known as the Lindner has been applied on the Continent, but the author has not received any particulars of engines of this description

The information which has hitherto been published in England with regard to compound engines is not of an extensive character, but one of the most complete sets of figures which has as yet come under the notice of the author is that which Mr Wilson Worsdell, the Locomotive Superintendent of the North-Eastern Railway, has been good enough to supply with regard to the working of compounds made to the design of his brother, Mr T W Worsdell of that Railway, at a period when he was the Locomotive Superintendent This voluminous contribution embodies in all about seventeen different statements, and as it would be impossible to publish these figures in their entirety owing to their being so extensive, the author has therefore extracted a condensed statement which shows that 447 non-compound engines ran 14,807,261 miles with a coal consumption of 4,829 010 cwt, giving an average of 36 52 lbs per mile, and that 395 compound engines ran 13 799,482 miles with a coal consumption of 4,122,239 cwt, giving an average of 33·45 lbs per mile, or a saving of 8 40 per cent

While discussing the subject of coal consumption, it is natural to revert to an investigation of grate areas and by consulting the different diagrams see Plates LXIX to LXXIV, it will be found that this detail varies from 14 25 to 50 6 square feet in the four-wheels coupled engines, 16 6 to 27 square feet in the six wheels coupled engines, 17 75 to 20 8 in the single wheel engines, and 19 6 to 76 square feet in the compounds, omitting in the latter case the small engine No 65 of the Norwegian State Railway which has only 13 98 square feet It will be noticed that in each case the range is wide, and the author concludes that this is in a great measure due to the variation of quality in the class of coal which can be used in the various districts in which the engines run Mr Webb, the Chief Mechanical Engineer of the London and North-Western Railway, has given the author particulars of one week's running between London and Carlisle by the 7ft compound express passenger engine "Greater Britain," No 54, from the 17th April to the 22nd April 1893, during which period the mileage run was 3 588, in 76 hours and 7 minutes, actual running time, and in 82 hours and 12 minutes including stops, with a total coal consumption excluding lighting up of 47 tons 17 cwt, giving an average of 29 87 lbs per mile On the Irish railways compounds have been experimented with by the Great Southern and Western Railway Company, also by the Belfast and Northern Counties Railway Company, and on the latter railway several compounds have been at work for some time with very favourable results The passenger engine is represented by No 56 The consumption of fuel of South Wales

coal is reported to show an advantage in favour of compounds varying from 11 17 per cent to 17 74 per cent

With regard to American practice in compounds, Mr D L Barnes reports that the compound principle has been applied to some express engines with satisfactory results, as far as hauling of trains and economy is concerned These are running on the Pennsylvania Philadelphia and Reading Central Railroad of New Jersey, and the Atlantic City Railroads, also some built at the Baldwin Locomotive Works that have made some very fast time with comparatively heavy trains The author has shown on the different diagrams, see Plates LXIX to LXXIV, the main details of the compound engines used by the Philadelphia and Reading No 57, the Baltimore and Ohio, No 59 and the Central Railway of New Jersey, No 60, and also the express Columbia, No 58 made at the Baldwin Locomotive Works It will be noticed that of these four engines the weights are very much in excess of any of the weights of engines other than tank, on any of the English railways, although the Eastern Railway Company of France have engines No 29 which approximate to these figures

After such examples it may now be considered convenient to refer briefly to the use of the increased pressure in compounds To obtain the best possible results from a compound engine, it has been found by experience that the high pressure cylinder should be made at least 1 inch larger in diameter than one of the cylinders of a simple engine having the same power At the same time the boiler pressure must be increased from 20 lbs to 30 lbs per square inch, and Mr Worsdell in his latest compound engine No 55, has gone still further, and introduced 40 lbs per square inch more than the simple engine No 9 working in the same link The total pressure of the compound is 200 lbs per square inch, which is the maximum in this country, the Irish compounds mentioned before only being 170 lbs per square inch, also exceeding the American compounds which are 180 lbs per square inch, and following very closely upon the French practice of which the highest boiler pressure recorded is that shown by the Paris Lyons and Mediterranean Company, 212 9 lbs per square inch the Northern and Southern Railways of France having 198 6 lbs per square inch

From the foregoing statements it appears that a large and varying amount of fuel economy has been attained by the compound system, and the question now arises, will it cover a reasonable interest on the extra first cost and repairs? The simple engine is the product of years of accumulated experience and therefore has this great advantage over the compound, but it is well known that the heavy repairs are carried out in the firebox and boiler, the mechanism of the engine requiring the least attention In compounding, higher pressures are required therefore more frequent boiler repairs will be the outcome, but with regard to the other parts of the engine they should not be excessive, except when by the application of three or more cylinders, the expenditure may be expected to be greater Undoubtedly the strongest argument in favour of compounding, points to its almost exclusive use in those countries where fuel is much more expensive than in England On the continent and in America it appears to be gaining favour, if numbers are an indication, and the success of the Worsdell Von Borries engines on the North Eastern Railway, and the continued and extended use of the Webb system on the London and North-Western Railway, are strong points in favour of the system

(3) *Improvements in distribution and balanced slide valves* — Balanced slide valves have not been used to any great extent in England, but numerous experiments have been tried at various times, which have tended to show that the difficulties of repair were such as to retard their introduction A paper by Mr J C Park on balanced valves was printed in the proceedings of the Institution of Civil Engineers, Volume XCVIII page 369,

in which he gives diagrams of many designs that were tried on the North London Railway On the other hand, the author wrote a paper which was also printed in the transactions of the above Institution Volume XCV, page 167, in which he gives results of some experiments with a valve dynamometer, which in his opinion at that time tended to show that, as the co-efficient of friction was only 068 the gain to be anticipated by using a balanced valve was so slight that it would not be worth while departing from the simple form of D valve The experiments recorded in the author s paper were all made with valves resting against a vertical face Since the time when that paper was written he has had reason to believe that the same view cannot be held with regard to valves resting on a horizontal face where the wear and tear seem to be greater, possibly on account of the fact that the lubricant is more readily swept away by any water that may get into the cylinders The use of valves in the horizontal position is almost universal in the United States, *where cast-iron valves are the rule and they are very frequently of the "Richardson'* semi balanced type Mr W. Worsdell, of the North Eastern Railway Company, has supplied particulars of a piston valve used on that Railway which is responsible for saving 50 per cent wear and tear in the slide valves and motion, as compared with ordinary slide valves working at the same pressure, and performing the same duty It is used in express engines at 175 lbs per square inch Mr. Johnson, of the Midland Railway, has tried piston valves for some years, and recently he has fitted five express engines which are reported to have used 6 8 lbs of fuel per mile less than engines with ordinary valves in the same link On the London and North Western Railway the matter has also received attention On the Lancashire and Yorkshire Railway the author has tried a form of partially balanced valve placed above the cylinders which so far has shown great advantage in wear, and those engines with which it has been fitted show an economy in fuel, which may be accounted for by the fact that the steam chest stands well up in the smoke box and therefore obtains some advantage from the heat of the smoke box gases

(4) *Engine building regarded from the point of view of diminishing the strains on the permanent way*

(5) *The effect from this latter point of view of the compound principle* —

When engine building is regarded from the point of view of diminishing the strains on the permanent way the internal disturbing forces of the locomotive, which tend to unsteadiness in running, must be considered These forces originate from the revolving and reciprocating parts of the motion, they are intensified at high speeds, and many attempts have been made to perfectly overcome these defects However it still remains that balance weights have to be placed on the rim of the driving wheels, which only truly balance the revolving parts and it is purely imaginary to suppose that these weights will perfectly balance the reciprocating parts This could only be accomplished perfectly by introducing equal and opposite reciprocating weights, but which is never done on account of extra cost, friction and complication By attempting to overcome this difficulty with weights in the wheels an auxiliary vertical force is introduced which tends to increase the pounding action upon the rails when descending and decrease the adhesion during ascending. Some very interesting experiments upon the pressure between the wheel and rail due to counterbalance have recently been made by Professor Goss at Purdue University (*see page 270 and plate No LVIII in this volume*), where it is shown that the wheels left the rails at certain speeds This emphasises the well known fact that all reciprocating parts should be as light as possible consistent with safety, strength, and durability because they not only add to the gross weight of the engine but also, for portions of the stroke are retarding agents The result of these disturbing forces are A fore and aft motion caused by the revolving parts meeting a horizontal component, and a rolling sinuous motion set up by the vertical force acting first upon one side, and then on the other, of the engine of the two the latter is of the lesser importance.

To prevent disturbing effects, long connecting rods are essential while the wheels should be placed well apart, as the weight of the engine is then distributed over a greater surface of the road, and consequently, strains per sectional area are diminished but at the same time an extra length of rigid wheel base acts severely on the permanent way when passing round curves A high centre of gravity promotes ease in running it is consequently *less destructive to the road, as the weight of the engine is almost entirely thrown more* direct on to the vertical centre of the outer rail preventing the wheels from mounting when passing round curves at high speed * All things considered point to the advantage of high centres of gravity, and the use of wheels with large diameters for the continuous high speeds which are now rendered possible by the improved roads and signalling The piston speed becomes less and, therefore, the retarding effects of the reciprocating parts are reduced

Author has been given a statement supplied by Mr Barnes relative to the effect of the disturbing influences of compound engines on the permanent way, and he can only endorse those views with relation to this country

(6) Descriptions of individual engines —

The engineers of the various railways who were applied to for information have sent forward figures which represent their practice with express engines and from these figures statements have been prepared and arranged in such order as to admit of an easy and rapid comparison Of these statements, the diagram B, and a series of outline diagrams to a small scale of the different locomotives C, have only been reproduced, *see plates LXIX to LXXIV* Each engine in diagram C has been numbered with a specific number that will be found repeated throughout, thus if information relating to No 30 is being looked out on the diagram, a reference to the small diagram of the engine No 30 will show at once the locomotive which corresponds to that number

The author will now proceed to delineate some of the express engines, and to facilitate this he has divided them into groups, *viz*, 4 wheels coupled, 6 wheels coupled single wheels, and compound engines It will be found that many have been touched upon, but it is not the wish of the author that these remarks shall in any way supersede the diagrams and other graphic statement, as they are alone comprehensive Some have not received descriptive attention, but their interesting features will be readily gained by consulting their respective statements

On the Lancashire and Yorkshire Railway, the heavy gradients and sharp curves necessitate the use of coupled engines (1 and 2 on diagrams) for the heavy express work an engine (2 on diagram) with 6 feet driving wheels is used, but the fastest trains, running long distances without a stop are worked by a four wheel coupled engine (1 on diagram) with 7 feet 3 inches wheels The latter engines carry a boiler pressure of 160 lbs per square inch and are fitted with the 'Joy' system of motion These engines are suspended on the driving wheels with a form of spring which has been designed with a view to simplicity, and great facility for repair It is made of two parts which are exactly alike, and tied together by two bolts only The pair is placed in an open suspended hanger, the upper portion of the spring bearing against the horn keep, and the lower portion on a single adjusting screw By slacking this one set screw, the spring may be removed from the engine The automatic vacuum brake is applied to the four driving wheels, and to the tender wheels also throughout the train It will be noticed in most of the English American and continental tenders that the capacity for water varies in a marked degree from those of the Lankshire and Yorkshire, and London and North-Western Railways in which only 1 800 gallons of water are carried The relative weight of the tenders and their water capacity are shown on diagram B The reason for these

* See also Volume IV, page 135 and plates XXVI

tenders carrying so small a quantity of water is on account of the use of the well known apparatus invented by Mr J Ramsbottom By this arrangement, water is picked up from troughs placed between the rails whilst the train is in motion and it has the advantage of not only relieving engines from hauling the extra load of a heavy tender, but it enables express trains to run longer distances without stopping to take in water It prevents serious blocks on a crowded line congested with traffic, like the Lancashire and Yorkshire, by allowing goods trains to proceed at once to their destination without otherwise having to stop for water, and this crowded line has been thus relieved to a great extent It also affords a means of opening out fresh sources of water supply, by taking advantage of a stream of good water which may flow near the rail level alongside of the line, without the expense and labour of pumping It often thus saves the necessity of purchasing water from an expensive city supply The arrangement used on the Lancashire and Yorkshire Railway is supplemented by an invention of the author's by means of which the scoop is dropped into, and raised from, the water, by utilizing the vacuum brake pipes which are put in connection with a lifting cylinder

The Midland Railway Company use the four wheels coupled engine No 3 on their line where the gradients are heavy, but where they are easy, as between London and Nottingham the single wheel engine No 50 is used Both of these engines designed by Mr S W Johnson, are of the inside cylinder type and worked by "Stephenson s" link motion They are fitted with steam brakes which act upon both the engine and tender automatically in combination with the vacuum brake on the train Both have also steam sanding apparatus, which injects the sand directly under the tread of the wheels The single wheel engine No 50 is of a most recent type, and is as remarkable for its low consumption of fuel, *viz*, from 20 to 23 lbs. per mile, and economical working, as for its graceful outline, the production of a skilful designer It has double frames, the crank axle having bearings in both, which arrangement would enable the engine to keep the road if the crank axle broke at the webs but the trailing wheels have outside bearings only It is timed to run between London and Nottingham a distance of 124 miles, without a stop, at a booked speed of 53 5 miles per hour with a gross load of 215 tons. This combination of circumstances caused the author to note the remarkable consumption of fuel The Manchester, Sheffield and Lincolnshire Railway Company employ the four wheels coupled engine No 4 which is of the ordinary inside cylinder type, with the valves between, worked by "Stephenson s link motion, and having a four wheels leading bogie Steam sanding gear is arranged to the driving wheels, and the vacuum brake works automatically on the engine tender and train It hauls the fast express trains between Manchester and Grantham in connection with the Great Northern Railway Company to Kingscross, London, at an average speed of from 45 to 49 miles per hour, with net loads of 140 tons Considering the heavy gradients of this line between Manchester and Sheffield, the consumption of 26 lbs of coal per train mile is exceedingly light.

The London and South Western Railway adopt the very powerful engine No 5 to work the fast express trains It has four wheels coupled, the driving and trailing springs of which are compensated and a four wheeled leading bogie The cylinders are 19 x 26 inches, and placed outside the frames, the valves being inside, and worked by "Stephenson s' link motion This engine is fitted with "Adam's Vortex Blast Pipe' which gives a very even draught, and a soft exhaust The piston rods are carried through each of the cylinder covers A steam brake is used on the engine, and worked in combination with the automatic vacuum brake on the train This engine runs at the high average-rate of 51 miles per hour with such heavy loads as 230 tons net, and the consumption of Welsh coal is 27 to 31 lbs per train mile

The gradients of this Company s line are very trying in many parts, as between London and Southampton

This engine, in many of its features, is similar to the practice carried out in America, and a series of articles comparing the details of this engine and a typical American passenger engine appeared in the "American Engineer," Volumes LXVII and LXVIII, 1893 and 1894 From this comparison, the author gathers that the principle differences are, that the American engines are fitted with bar frames, steel fire box, and extended smoke box

The South Eastern Railway Company work their fast traffic with a four wheels coupled engine (No 6) which also has a four wheels leading bogie The cylinders are inside the frames with the valves between, and worked by "Stephenson s link motion The valve gear of this engine is reversed by an admirable steam reversing arrangement, which dispenses with manual labour on the part of the engineman during the operation of reversing, and permits of a fine adjustment of "cut offs, but has the drawback of being inoperative when the engine is not in steam

The boiler of this engine is without dome, the steam regulator being placed in the smoke box *and the main steam pipe inside the boiler, is perforated on the top,* similar in this detail, to that of engine No 51 of the Great Northern Railway The average speed of these engines is 47 2 miles per hour, for a distance of 75 5 miles, with a net load of 186 tons and the consumption of coal is 32 8 lbs per train mile The gradients on this Company's line are moderately heavy. The engines are fitted with the automatic vacuum brake The Great Eastern Railway Company use the type of engine shown as No 7 which is a four-wheels coupled, but has not the leading bogie, which has been characteristic of the engines already examined The leading end of this engine is carried by a pair of wheels, which have four journals, the outer pair taking the principal portion of the weight, while the inner are devoid of collars, which give to the bearings free sliding movement when passing round curves The cylinders are fixed inside the frames with the valves beneath, which arrangement effectually drains the cylinder from condensed steam, and also allows the valves to fall from their faces when running with the regulator closed The valve motion is of the "Stephenson' type, the balancing of which is *effected by means of a spring The average speed attained by these engines is* 45 2 miles per hour, for 55 75 miles, with a coal consumption of 33 9 lbs per train mile, and a net load of 196 tons. The gradients traversed by these engines are heavy the curves sharp and numerous, and the Westinghouse brake operates on the engine tender and train Mr Holden has also designed an arrangement for the application of liquid fuel and applied it to several express engines on this line with very encouraging results The blast pipe orifice can be enlarged from 50 to 60 per cent which reduces the wear and tear of the fire box and tubes and also prevents the emission of sparks and ashes The absence of *perpetual firing is very* marked to those accustomed to travelling on the foot plate of engines hauling heavy and fast express trains

The author has been supplied with particulars of two types of engine Nos 9 and 55, employed by the North Eastern Railway Company for working the fast Scotch dining car trains between York and Edinburgh Both of these engines are remarkable for their cylinder capacity boiler power, and for the novel departure from the ordinary English practice in placing the valve chests outside the frames a method largely used on the *Continent This arrangement became necessary by the use of cylinders 20 inches and* 28 inches diameter for the compound and 19 inches diameter for the simple engine The motion is of the "Stephenson type and connected to the valves by means of a rocking shaft The crank axles of these engines are of a special design, introduced by Mr T W Worsdell when Locomotive Superintendent of the Great Eastern Railway The webs are circular discs which enables the thickness to be diminished proportionately with increased width, and also the crank can be finished entirely in the lathe The fuel and water capacity of the tenders for these engines is very large, *viz*, 11,200 lbs

of coal, and 3,940 gallons or nearly 18 tons of water, and each engine is fitted with both the Westinghouse and automatic vacuum brakes. The engine indicated by No. 9 is 'simple,' but the other No. 55 is compounded on the "Worsdell and Von Borries" system. The boiler pressure of the former is 160 lbs. and that of the latter 200 lbs. per square inch. This system of compounding was first designed and introduced on the Great Eastern Railway by Mr. T. W. Worsdell, late Engineer of the North-Eastern Railway, and the latter Company have upwards of 270 compounds at work, while there are at least 1,000 'Worsdell and Von Borries' engines working abroad. These two engines have been in competition on the North-Eastern Railway, under the same conditions regarding loads and booked speeds, with the result that the compound shows a saving at 4.4 lbs. per train mile. The average speed of each engine was 47.75 miles per hour with a nett load of 182 tons and the consumption of coal was 32.8 lbs. for the simple and 28.4 lbs. for the compound per train mile. The gradients traversed are heavy between Edinburgh and York, and the longest run without a stop is 124.5 miles.

The "London, Brighton and South Coast Railway Company's" well known engine of the "Gladstone" type No. 8 was designed by the late Mr. Stroudley in 1881, and is still the type of engine used for fast traffic on the Brighton line. There are many remarkable features about this engine, and it stands alone from the usual English practice. It received much attention and was minutely described in a paper, contributed by Mr. Stroudley to the "Institution of Civil Engineers," Volume LXXXI. 1885, many of its details being thoroughly discussed. Although it is true that there are engines with their leading wheels coupled to the drivers on the Great Northern Railway, and that Mr. Adams has designed some for the London and South-Western line, the "Gladstone" class remains unique as regards so large a diameter as 6 feet 6 inches for the leading wheels coupled to the driving. The trailing end is carried on a small pair of wheels 4 feet 6 inches diameter. The cylinders are placed inside the frames with the valves beneath and actuated directly by the "Stephenson" link motion, the reversing of which is performed by a compressed air reversing gear. It may be observed that the outside cranks are placed upon the same side of the axle as the inside ranks instead of upon the opposite, as is the usual practice which was fully discussed in the paper already referred to. The average weight of trains hauled by this class of engine is 269 tons net at the high average speed of 43.3 miles per hour, over heavy ruling gradients, and the Westinghouse automatic air brake is fitted throughout the train. The coal consumption is 30.93 lbs. per train mile and the boiler capacity is very large with a total heating surface of 1,485.3 square feet.

The London Chatham and Dover Railway Company use the engine No. 11 for fast traffic. It has four wheels coupled and a leading bogie, steam sanding gear being arranged to inject sand under the tread of the driving wheels, the weight on which is carried by Timmis' Patent springs. The cylinders are inside the frames, with the valves between, and worked by "Stephenson's" link motion. They run the fast express trains between London and Dover, in connection with the Continental Boat Service. This distance is 78 miles and the time allowed is 104 minutes, the average speed being 45 miles per hour. The weights of these trains vary from 150 to 220 tons net, and some parts of the road traversed has ruling gradients of 1 in 100. The engines work satisfactorily with a coal consumption of 31.5 lbs. per train mile, and the Westinghouse automatic air-brake is fitted throughout the train.

The Caledonian Railway Company utilize the engine No. 12 to work the West Coast corridor, first and third class dining saloons trains over their road, between Carlisle and Glasgow. These engines have four wheels coupled, 6 feet 6 inches diameter, and a four wheels leading bogie. The weight on the driving wheels is carried by four Timmis' springs and that on the trailing wheels by laminated springs. The cylinders are 18

inches diameter by 26 inches stroke, and are set inside the frames with the slide valves between, which are controlled by ordinary gear with large working surfaces The exhaust from each cylinder is divided, the upper portion passing directly to the blast pipe, the orifice of which is annular whereas the lower portion travels round the cylinder barrel, a course perhaps of questionable utility The boiler barrel is made from two plates, which necessitates them being very wide, but on the other hand, it dispenses with a circular seam of rivets It may be interesting to mention here that the barrel of the engine No 5 (London and South-Western Railway) is constructed in a similar manner, excepting that a circular butt joint is formed and a ring 8 inches wide and ⅞" thick shrunk on The road between Carlisle and Glasgow is heavy, there being gradients of 1 in 80 1 in 75, etc., for many miles, but these trains attain an average speed of 48 to 49 miles per hour

Mr. Manson has designed the engine No 13 for the Glasgow and South Western Railway Company, to work the dining and other express trains which travel between Carlisle and Glasgow (St Enoch) in connection with the Midland Company's trains The cylinders are placed inside the frames but the valves, which are of the partially balanced type, are located above the cylinders and actuated by the ordinary "Stephenson's" link motion, through a rocking shaft A notable point relating to the cylinder is the very large area of the exhaust ports Steam reversing gear is provided which is quick in action, less laborious to manipulate than either the lever or screw, but of course is inoperative when the engine is not in steam The trains referred to traverse over a distance of 115 5 miles on this Company's line between Carlisle and Glasgow, and are hauled by these engines at an average speed of 46 5 miles per hour, with a coal consumption of 34 lbs per train mile It may be noted that such gradients occur on this route as 1 in 67, 70, 100, etc, for considerable distances

The Great Southern and Western Railway Company, Ireland, under the direction of their Locomotive Engineer, Mr Ivatt, employ the four wheels coupled express engine No 17 to work the American Mails between Dublin and Queenstown The cylinders are 18 by 24 inches and placed inside the frames, with the slide valves between, and controlled by the "Stephenson's" type of motion The coupled driving wheels are 6 feet 7 inches in diameter, and are placed in the front and back of the fire box, with a short rigid wheel base of 8 feet 3 inches The leading end of this engine is carried on a bogie having four wheels each 3 feet diameter The gauge of this railway is 5 feet 3 inches, and consequently the bearings are of very ample dimensions The bearing springs for all the axles are of the volute pattern, and for the driving wheels three are employed, side by side, under each bearing Two springs are sufficient for each bogie wheel one placed upon each side of the hornblock, which are connected and brought into play by means of a crossbar attached to the axle box This arrangement of bogie springs is also used by the Lancashire and Yorkshire Railway Company The tenders carry 2,730 gallons of water and about 3 5 tons of coal. The trains are light 100 tons net and excellent speeds are attained averaging 46 6 miles per hour, with a maximum of 70 miles per hour, on a low consumption of 23·3 lbs of South Wales steam coal per mile The gradients near Dublin and Cork are moderately heavy, one bank on leaving Dublin rising 1 in 85 for a distance of 4½ miles The automatic vacuum brake is used on the engine, tender and train

The New York Central and Hudson River Railroad Company are celebrated for what may be regarded as the most advanced type of locomotive practice in the United States Representations are given in Nos 20, 21, these engines being designed by Mr Buchanan, and it may be stated that American locomotives vary in a marked degree from the English practice, and many discussions comparing the two systems have taken place The arrangement of the wheels practically resembles the English express

type The driving and trailing are coupled and the leading end is supported by a four-wheeled bogie, the tenders being fitted with water scoops The cylinders of each engine are 19 inches diameter by 24 inches stroke, and placed outside the frames being cast with a saddle on which the smoke box rests The valves are of the 'Richardson' balanced system, and placed on the top The motion is of the "Stephenson" type, connected to the valves through a rocker shaft which is the ordinary method in the United States Rectangular bar frames are used, with fire box carried above the frame which enables it to be wider, and the trailing axle being placed underneath greater length is obtained than in the usual English practice The boiler capacity and heating surface is also much in excess advantage being gained because of the ability to pitch the boilers higher, but on the other hand inferior fuel demands the greater heating surface In 1892 Mr Buchanan designed the engine No 21 to run the "Empire State Express" train between New York and Buffalo, and it was claimed to be the fastest train in the world The load hauled was light and the road easy but the attainment of an average speed of 52·1 miles per hour for a distance of 440 miles is certainly a creditable performance. The engine No 20 has additional heating surface and grate area, and the driving wheels are increased from 6 feet 6 inches to 7 feet 2 inches diameter Mr. Buchanan has supplied the author with particulars of speed recorded on the 9th of May 1893 by this engine, which is well known by its No 999 During this journey 143 miles was traversed in 2 hours 45 minutes, 148 miles in 3 hours 4 minutes, 149 miles in 2 hours 50 minutes averaging 53·4 miles per hour Between *Syracuse and Buffalo a speed of 74·63 miles per hour was maintained for several miles*, the maximum speed being 100 and 102·8 miles per hour for 1 mile each respectively

The express engines No 24 used on the Pennsylvania Railroad which have been constructed under the direction of Mr Ely are of interest, as showing what one of the leading Railways in America consider the best type of locomotive for their heaviest and fastest work These engines are fitted with the Belpaire form of fire box and have very large heating surfaces and grate area, working pressure 175 lbs per square inch The engine is fitted with the Westinghouse Brake and also an arrangement for heating the carriages by steam like many of the American engines, and which is now being done to a great extent on the English and Continental Railways These engines run at a speed of 46·08 miles per hour for a distance of 137·6 miles The tender carries 3,000 gallons of water, and is fitted with the water pick up arrangement

The State Railway of France employ the engine No 25 which is chiefly interesting for its valve gear It was designed by M Bonnefond the main features being that the steam and exhaust ports are independent The admission ports are at the top and the exhaust at the bottom of the cylinder The 'Bonnefond' gear in some respects bears the same relation to the locomotive as the 'Corliss gear does to the stationary engine The cylinders are $17\frac{5}{8}$ inches diameter by $25\frac{5}{8}$ inches stroke and placed outside the frames in front of the leading wheels The driving wheels are four coupled 6 feet $7\frac{1}{4}$ inches diameter and both are placed in front of the fire box which also distinguishes this engine from the ordinary practice The leading and trailing ends are each supported on smaller wheels 4 feet 4 inches and 3 feet $8\frac{1}{2}$ inches respectively The tenders are small, carrying $4\frac{1}{2}$ tons of fuel and only 1,650 gallons of water Briquette fuel is used and the consumption is 26·9 lbs per mile, the average speed being 40·6 miles per hour, and the loads 138·9 tons net The engine is fitted with the 'Wenger" brake

The Paris Lyons and Mediterranean Railway Company have supplied the author with particulars of two engines the first being No 26 a simple expansion engine of the outside cylinder type with four wheels coupled and a leading bogie The second engine

No 61 is a four cylinder compound and having the same general arrangement of wheels as No 26 It has been designed recently not only to obtain economy in fuel, but also to decrease the total weight of the engine The boiler barrel has been reduced 1 foot 2 inches in length, and is fitted with the 'Serve' or feathered tubes A further reduction has been made by substituting steel for copper in the fire box, but the pressure has been increased from 156 lbs to 212 8 lbs per square inch The high pressure cylinders are mounted outside the frames, near the centre of the engine, and are connected to the trailing wheels The low pressure cylinders are fixed inside the frames at the leading end, under the smoke box, and are coupled to the forward driving wheels

The "Walschaert' system of motion operates the high pressure valves which are on the top of the cylinders, and a special arrangement of motion without eccentrics controls the low pressure valves, which are brought through the frames to prevent overcrowding Steam can be admitted from the boiler into the intermediate receiver between the high and low pressure cylinders, but the high pressure exhaust cannot pass direct into the air The low pressure exhaust pipe is rectangular and can be varied by means of movable cones The reversing is accomplished by means of a steam reversing gear which operates the valves for the four cylinders and fixes, independent of the driver, a ratio for each point of "cut off" Steam sanders are used for the forward driving wheels, and the Company has adopted the 'Westinghouse Henry' brake. The coal used on these engines is composed of two thirds slack and one-third briquette

The express traffic of the Paris and Orleans Railway Company *is conducted* by engine No 27, which has many interesting features in differing from the usual practice The four coupled wheels 7 feet $0\frac{3}{4}$ inches diameter are placed forward of the fire box, the leading and trailing being 4 feet 2 inches diameter. The main frames are inside and run from end to end of the engine, supporting the three leading axles with inside bearings, whereas the journals for the trailing wheels are outside, and attached to a short length of frame plate to facilitate the trimming of the box The weight on the four coupled wheels rests on one spring upon each side of the engine The cylinders are inside the frames very much in advance of the leading wheels, which is necessary on account of the connecting rod being coupled to the forward drivers The valves are outside the frames, and are driven by the "Gooch' link motion The boiler barrel has an exceptional length of 16 feet $5\frac{7}{16}$ inches, and the heating surface of the tubes is 1506 6 square feet It is also fitted with an arrangement for circulating water and collecting sediment A novel departure of fire box construction is the method of staying the crown, *which really consists of a number of channel steel sections rivetted* together The other parts are of copper and the arch is of the 'Ten Brinck' type The engine has two domes, one above the fire-box and the other near the chimney, the pair being connected These engines haul trains of 208 6 tons net at an average speed of 48 4 miles per hour, consuming 42 lbs of fuel per train mile, composed of 70 per cent. briquette and 30 per cent. small coal

The design resembles very much that of the Austro Hungarian State Railway Company, with the exception that the cylinders of the latter are placed outside as represented by No. 34

M Salomon Engénieur en chef of the Eastern Railway of France, has designed engine No 29 for the express traffic of that railway Its most notable feature, the double boiler suggested by M Flaman, records another departure in locomotive construction It consists of two barrels, besides the fire box the crown of the latter being *constructed of corrugated steel, and arched The top of this box is as high as the lower* cylindrical part of the boiler, consequently the depth as compared with an ordinary box, is very much increased and therefore a greater space is gained for the combustion of

furnace gases. Further heating surface is obtained by substituting the "Ten Brinck" type of water bridge for the ordinary brick arch. The lower barrel is completely filled with 304 tubes; consequently the whole of this space can be filled with water, and therefore (with the volume of water at its normal level, i.e., the centre line of the upper barrel which leaves a steam space of 63·25 cubic feet) the reserve power of this boiler is considerably increased. Three large openings are provided between the two barrels, besides the heating surface of the top of the fire box acting directly upon the water in the upper barrel so that ample circulation is provided. The grate area is 26 square feet, and the heating surface amounts to 1,664·3 square feet for the tubes and 146·44 square feet in the fire box. It may be interesting to remember that Mr. Ramsbottom read a paper before the Institution of Mechanical Engineers, in 1849, in which he suggested and gave the description of a similar boiler. The cylinders are 19·68 inches by 25·98 inches and mounted outside the frames near the centre of the engine with the valves placed on the top. The valve gear is of the "Stephenson" type, with outside eccentrics and ordinary reversing arrangements. The four driving wheels are coupled 6 feet 10¼ inches diameter, and the leading end is carried on a four wheels bogie. Steam sanding apparatus is used, and the engine is fitted with the Westinghouse brake. Trains of 201·5 tons net are hauled at an average speed of 42·5 miles per hour over grades of 6 millimetres per metre, with a fuel consumption of 41·7 lbs. per mile, consisting of 80 per cent. slack and 20 per cent. briquette.

The novel type of engines employed by the Belgian State Railway Company to work their fast traffic is illustrated by No. 31. The cylinders are 19·68 inches by 23·62 inches and placed inside the frames, with inclined valve chests outside, and the valves are controlled by the "Walschaert" motion. It has four coupled wheels 6 feet 10 inches diameter, also leading and trailing 3 feet 11¼ inches diameter, the former being mounted in a radial axle box. The crank axle has a central support attached to an intermediate frame. A somewhat similar arrangement was tried by Mr. Webb on the London and North Western Railway in 1887. An earlier arrangement of the same kind was made by Robert Stephenson on the locomotives built for the Manchester and Leeds Railway in 1840. The frames are outside and all axles have outside bearings only. The bearing springs are laminated and both curved and straight, the usual camber having been abandoned in this case as also be observed in many Continental engines. Another feature of interest in this engine is its fire box, which is unusually long and wide. The front portion and fire grate is reduced in width in order to place it between the rear coupled wheels. This engine has been specially designed for hauling trains of 147·6 tons net, at an average speed of [illegible]5 miles per hour on a coal consumption of 43·2 lbs. per mile, the quality being inferior to English.

The express engine of the Dutch State Railway is illustrated by No. 37 and was built by Messrs. Beyer Peacock and Company, Manchester. In many of its principal details the engine closely resembles the English practice, and is remarkable for a light weight of 40 tons in working order, when compared with its large boiler and cylinder capacity. The cylinders are 18·11 inches × 25·98 inches, and inside the frames with the valves placed between, worked by "Stephenson's" link motion and reversed by means of a screw and long lever. There are four coupled wheels 7 feet diameter with the fire box between, the leading end being carried by a pair of smaller wheels 4 feet diameter. This axle is provided with outside bearings only, the boxes of which have sufficient side play in the horn-blocks, to admit of the engine passing round curves freely. The driving and trailing axles have both inside and outside bearings, which is generally the case when double frames are employed. The fire box is of the "Belpaire" pattern, and the shell is fitted with suitable doors for washing the top of the inside fire box. The boiler contains 220 tubes 1¾ inches outside diameter, and the heating surface is 983·68 square feet for the

tubes, and 105 23 square feet for the fire box, with a grate area of 23 55 square feet The fuel is composed of ordinary coal and briquettes and the consumption is 31 5 lbs per train mile The average rate of speed attained by these engines is 47 5 miles per hour, with net loads of 142 5 tons, and the road is easy with the exception of one bank on leaving Liege which has a gradient of 1 in 62 for 5 miles

The author does not propose to deal with the 6 wheels coupled engines in this manner, as from an ordinary point of view they are not suitable for high speeds The single wheel engines will now, therefore, receive attention with a reminder that the Midland Railway Company's single engine No 50 has been already dealt with

The Great Northern Railway Company are celebrated for their handsome outside cylinder single wheel express engine No 51, which has received universal admiration from all Engineers It was designed by Mr P. Stirling about 26 years ago, and its reproduction at the present day speaks very highly for the forethought which prompted its introduction The cylinders are 18 inches diameter by 28 inches stroke, which is very long when compared with the American engines having only 24 inches stroke for cylinders 20 inches diameter No 23 The valves are placed inside the frames and are driven by the ordinary type of link motion On account of the great increase and weight to be hauled, Mr Stirling has recently built a new class of single wheeled engine having cylinders 19½ x 28 with a much greater heating surface and grate area The driving wheels are 8 feet 1½ inch diameter, and are, as far as the author is aware, about the largest running on any railway excepting the old "Cornwall on the London and North Western Railway which has driving wheels 8 feet 6 inches in diameter. It may be noticed that the bogie centre pivot is not placed midway between the axles, but is 6 inches nearer the trailing axle, which renders an equitable distribution of weight on the wheels, and it is claimed that the engine passes round curves with greater freedom The bogie is steadied by running pieces bearing against brass slippers, on the underside of the main frame The absence of a dome necessitates the placing of the regulator in the smoke box, and the fixing of a "Hawthorn collecting pipe within the boiler. Mr P Stirling and his brother Mr J Stirling of the South Eastern Railway No 6, have always adhered to this system The East Coast route from London to Edinburgh is conducted by this Company as far as York, a distance of 188 miles, and a great reputation for punctuality of its trains has been acquired, at the high average speed of, in some of them, 55 6 miles per hour This engine performs this duty on a coal consumption of 34 lbs per train mile, with average trains of 200 tons net The longest run without stopping being 105 miles, causes the tender for this engine to be very large It has water capacity for 3 500 gallons, or about 15 5 tons, coal space for 5 tons and the gross weight when loaded amounts to over 40 tons The line is moderately heavy, with ruling gradients of 1 in 178 for 3 miles and 1 in 200 for 5 miles

The Great Western Railway Company conduct their express service with the 7 feet 1 inch single driving wheel engine No 52 It has inside cylinders 18 inches x 24 inches with the valves placed between and actuated by ordinary link motion This engine has double frames running from front to back, the leading and driving axle being fitted with both inside and outside bearings, whereas the trailing has outside only Side clearance is given between the leading and trailing axle boxes and their respective hornblocks which allows the engine to traverse curves with freedom Laminated springs are used for all wheels, supplemented by spiral for the inside bearings of the leading axle, and India-rubber washers are placed between the spring link and brackets. The boiler and fire-box are of the ordinary English type with the exception of the fire box crown which has been dished to form a channel 8 inches deep by 4½ inches wide, in order to obtain extra heating surface The automatic vacuum brake is fitted on the train, and a steam brake applies itself simultaneously on the engine when air is admitted into the train pipes

The ordinary large ejector is used for creating the vacuum, but the small ejector has been superseded by a pump which is fixed to the right inside frame and worked from the piston rod crosshead This arrangement has been a source of economy in the consumption of fuel The gradients are favourable for express traffic and high average speed, 53 5 miles per hour being attained between Paddington (London) and Swindon with this engine and a fuel consumption of 27 to 30 lbs of coal per train mile The express service on this Railway has almost always been worked by single driving wheel engines, but Mr Dean has recently designed a powerful 4 wheels coupled engine, because of the increasing weight of the trains It has cylinders 20 inches diameter x 26 inches stroke, and a total heating surface of 1 561 3 square feet and is consequently one of the most powerful engines of the simple type running in Great Britain.

The compound principle has already received much attention, and during its exposition the North Eastern Railway Company's engine No 55 and that of the Paris Lyons and Mediterranean, No 61 were thoroughly dealt on

The type of engine for the London and North Western Railway express traffic is represented by No 54 It is the eight wheels compound engine "Greater Britain" and sister engine to the "Queen Empress" which was exhibited at the World's Fair at Chicago during the year 1893 It has two high pressure cylinders of 15 inches diameter and one low pressure cylinder of 30 inches diameter both with a 24 inches stroke Joy's motion is dispensed with, the valves for the high pressure cylinders being placed inside the frames and worked by ordinary link motion, and the single eccentric introduced in the "Jeanie Deans" remains for the low pressure This engine is also remarkable in the extraordinary length of its boiler barrel which admits of both the driving wheels being placed beneath It is divided into two portions by means of a combustion chamber, the tubes to the fire box being 5 feet 10 inches and those to the smoke-box 10 feet 1 inch long This chamber is provided with a man hole of sufficient dimensions to admit of ready access to the tubes, and also with a hopper for the discharge of accumulated ashes by means of a valve worked from the footplate and which is kept in a closed position by a balance weight. From this construction a high total of 1505 7 square feet of heating surface has been obtained, made up as follows, *viz*, tubes 1,346 fire box 120 6, and combustion chamber 39 1 square feet, against the comparatively small grate area of 20 5 square feet In other respects, the engine resembles closely Mr Webb's general design of compounds The service in which this class of engine is employed is known as the "West Coast Joint" traffic and consists of the heaviest "Dining Corridor" and Scotch express trains on this system, running between Euston (London), Edinburgh and Glasgow The gradients over the north-western portion are heavy between Crewe and Carlisle, one of which over the Shap Fells is 1 in 75 for a distance of over 4½ miles An average speed of 47 66 miles is obtained with the low coal consumption of 31 07 lbs. per train mile, including 1 2 lbs per mile for lighting up.

The express service of the Philadelphia and Reading Railroad is worked by the compound engine No 57 which is remarkable for its two leading features, the "Vauclain" system of compounding and the "Wootten" type of boiler With these exceptions the main features of the body of the locomotive are similar to the ordinary American 4 wheels coupled express engines The system of compounding consists of four cylinders, two high pressure 13 inches diameter, and two low pressure 22 inches diameter, having 24 inches stroke, each pair being placed on each side of the engine and outside the frames. The high pressure cylinders are placed directly over the low pressure and their pistons are coupled direct to the same cross head The steam distribution is effected by a piston valve which works in a steam chest parallel to the two cylinders, and in about the same horizontal plane as the high pressure cylinder, that is, one valve controls the steam distribution of both the high and low pressure cylinders on the same

side of the engine This valve was fully described in the "Railway Engineer" Volume XI, of 1890, and is actuated by the ordinary "Stephenson" link gear The starting valve really consists of a small pipe from one end of the high pressure cylinder to the other, with a reducing valve midway, and when steam is admitted at one end, it is wire drawn to the other, and thence passes through the parts of the high pressure cylinder and the piston valve, to the low pressure It resembles more or less the pipes and cocks for indicating purposes and is controlled by the driver from the cab The chief interest in the "Wootten" boiler rests in its fire-box, which has been designed to consume "anthracite egg coal' and also "buck wheat or pea coal" It has a heating surface of 173 square feet and a grate area of 75 square feet It is kept above the frames extending across the whole width of the platform and the grate is composed of 21 water tubes, the space between each tube being occupied by fine cast iron bars A large portion of the grate is covered with fire brick and an arch or wall is placed at the junction with the barrel which retards the small coal from being drawn direct through the tubes, as a great difficulty is experienced in preventing air holes through the fire It also forms a combustion chamber immediately in front of the tubes and success in burning such small coal depends very much upon its dimensions It would be a difficult matter to adapt this boiler to English requirements, as its centre above rail level is greater than the English limit The four coupled wheels are placed under the barrel, in front of the fire box, the leading and trailing end being carried on a small pair of wheels. The cab is situated about midway, the driver's post being inside, while the stoker takes up his position at the back of the fire box. These engines make steam very freely, and haul heavy express trains of 247 tons net at the high average speed of 56 6 miles per hour, with a fuel consumption of 42 9 lbs per mile. The Westinghouse Brake is used throughout the train.

The experimental compound engine "Columbia" No 58 is specially designed for express passenger traffic and is known in that country as the "special high speed' type. The system of compounding is the "Vauclain" and the cylinders are of the same dimensions as No 57, which has just been described The boiler has a working pressure of 180 lbs per square inch and the barrel has a minimum outside diameter of 4 feet 8 inches. The grate area is 24 6 square feet, and the heating surface is as follows, *viz*, tubes 1,350 square feet, fire box 128 square feet the latter having been designed for the consumption of bituminous fuel The smoke box is fitted with the usual American extension The engine weighs in working order nearly 60 tons and is carried on four driving wheels, 7 feet in diameter, which are placed in front of the fire box, the rear end resting upon a pair of smaller wheels, while the front is supported by a two wheel truck The cylinders are outside the frames both in this engine and the previous one and the valves are worked through the medium of a rocking shaft. This arrangement of wheels admits of a much larger fire box than when a pair of larger driving wheels are placed at the end of the engine, and it may be noted that it is not the "Wootten type' The tender is of the American pattern, supported on a couple of four wheel bogies, and carries 3,600 gallons of water and 14 000 lbs of coal Experimental trials have taken place on the Atlantic City Railroad, the trains averaging upwards of 199 tons net, at a speed of 52 8 miles per hour, but data relating to coal consumption and gradients of the line have not been given

Just as it was going to be printed the administration of the Grande Société de chemins de fer Russes (actually Russian State Railways) have kindly supplied the author with extensive particulars for two types of engines used for working the fast traffic on these lines The four wheeled coupled engine No 69 is employed on the St Petersburg and Varsovie line It is compounded under the "Worsdell von Borries" system, and the high pressure cylinders are 1 foot $8\frac{1}{8}$ inches diameter (460 millimetres),

low pressure 2 feet $2\frac{3}{8}$ inches diameter (670 millimetres), the stroke in each case being 2 feet $1\frac{9}{16}$ inch (650 millimetres) "Joy's" motion is used for the steam distribution, and the valves are placed on the top of the cylinders The "Allen' double ported valve is used in both the high and low pressure cylinders, to obtain the requisite port opening with a short travel of valve The driving and trailing wheels, 6 feet 6 inches diameter (1,980 millimetres) are coupled, and the springs are compensated The front end of the engine is supported on a four-wheeled bogie with wheels 3 feet $7\frac{3}{4}$ inches diameter (1,110 millimetres). The average speed run by these engines is 35 miles per hour for a distance of 58 miles, and the net load hauled being about 206 tons The six-wheeled coupled engine No 70 is employed on the Nicolas line" and is also compounded under the "Worsdell von Borries" system, the high pressure cylinders being $18\frac{7}{8}$ inches diameter (480 millimetres), low pressure 2 feet $4\frac{3}{8}$ inches diameter (720 millimetres) with a stroke of 2 feet $1\frac{9}{16}$ inch (650 millimetres) The six coupled wheels are 6 feet $2\frac{1}{16}$ inches diameter (1 900 millimetres) and the front end of the engine is carried on a radial axle box with wheels 3 feet $8\frac{1}{2}$ inches diameter (1,130 millimetres), the tyres of the middle drivers being flangeless. The spring supporting the coupled axles are all compensated, and the steam sanding gear is used on both classes of engines, to eject sand under the driving wheels The valves for the high and low pressure cylinders are placed on the top, controlled by ' Joys motion, and the "Allen" double ported valve is used These engines travel at an average speed of 34 1 miles per hour The line is moderately heavy, one incline rising 1 in 166 for a distance of 9 6 miles Wood is largely used as fuel, and both these engines have large fire boxes, long boilers and extended smoke-boxes, and the "Wenger" class of brake is used.

The author also begs to acknowledge receipt of information from the following Railway Companies, but unfortunately it arrived too late for publication —

The Oudh and Rohilkhand Railway, Lucknow, India
The Bhavnagar Gondal-Junagarh Porbandar Railway, India
His Highness the Nizam s Guaranteed State Railway Company, Ld, Secunderabad, Deccan, India.
The Bengal Nagpur Railway, India
The Bombay, Baroda and Central India Railway, India
The Rajputana Malwa Railway, India
The North Western Railway, India
The Swedish Government Railways, Stockholm
The New Zealand Railway

BENGAL COAL.

Notes appertaining to the question of supplies for the Madras Railway, By Mr. A. Pilkington, Deputy Locomotive Superintendent

1. In Bengal there are large tracts of country known to be rich in coal of excellent quality, but which are as yet almost entirely neglected owing to want of communication either by rail or water. It can be only a short time before the coal-supplying area is more than doubled, and in the meantime those districts already served by railways are being rapidly opened up in all directions.

2. Much confusion is apt to arise when speaking on matters connected with Bengal coals, for the reason that the same term is used in several different senses. When first discovered, a seam of coal received the name of some village near which it was found. The name was then introduced into the geological nomenclature of the country to describe coal measures containing coal of the same nature as that found in the originally opened-up seam.* At the same time a large area of country has become known as a coal field and has taken its name from the originally worked seam. And again coal companies have taken their titles from the name of the coal on which they first commenced work. Thus on the "Karharbári" *coal-field* on which the "Raniganj" *coal company*—who first commenced operations on the Raniganj field—have extensive workings mention is made of "Barákar" *coal* measures, some of the seams found in the pits at Karharbari bearing coal of geologically the same description as that first found near Barakar village.

3. The principal coal-fields now being worked are as shown on the accompanying map Plate LXXV, they are known commercially† as the—

Karharbari field	Sanctoria field.
Barakar "	Raniganj "
Borrea "	Jherria "

4. On the Karharbari field there are seams of good coal known as the "Hill" seams, the "Upper" seam and the "Lower" seam. The only seam now being regularly worked is the 'Lower' seam. A small quantity of coal is taken from the "Hill" seams, but it is much inferior in quality to that found in the "Lower" seam. The "Upper" one bears coal of good quality, but, as it is a thin seam, it is not economical to mine it to any great extent.

5. On the Barákar field coal of all description, varying from very good to most inferior, is being worked. The best coal is, I think, that obtained from the Laikdee quarries; next in order I would place that taken from the "Khamardobie" and "Begunia" seams.

6. On the Borrea field the best and most worked seam is one of considerable thickness, the lower part of which is superior to the upper part. Much of the coal obtained

* In the same way geologists will speak of "Poona" rocks or "Deccan" trap as being found in quite the north of India, the strata referred to being similar in nature to that which in the early days of Indian geological surveying was first described and recorded in connection with surveys in the Deccan.

† I believe I am right in saying that geologists divide the district referred to into only four fields, *viz.*, the Raniganj, the Barákar, the Jherria, and the Karharbari.

on this field is of an anthracitic description, and is, as a rule, of only second quality A large quantity of very poor and dirty coal obtained from mines on this field has lately been exported from Calcutta under the name of "Borrea" coal, with the result that "Borrea" coal has now a bad name in the market But while all "Borrea' coal is thus condemned, there is much of it, obtained from the "Borrea" seam, which is of very fair quality

7. On the Sanctoria field there are three seams of excellent coal They are known as the "Deshergbur," the "Sanctoria," and the "Bamandiha" seams The Sanctoria coal is very rich in volatile matter, and is much in demand for gas-making The Desherghur and Bamandiha are in all respects good steam coals.

8 On the Raniganj field all coal found to the south east of Asansol is of inferior quality for locomotives that found in the "Siársol" seam is probably the best, but compared with that found further west, it is but a poor fuel There are still many mines being worked on the south east portion of the field, but most of the coal raised is for local consumption and does not find its way into the export market On the northern portion of the field there are two seams of good coal, they are the "Seebpore" and "Baraboni" seams

9 In the Jherria field there are some seventeen seams, the best coal being obtained from those known as "No. 12,' "No 13" and "No 15' The majority of the coal now being put on the market is of good quality, and like the Sanctoria coal contains a large quantity of volatile matter.

10 The chief prospective coal field in Bengal is that known as the "Palamau," but sometimes spoken of as the "Daltonganj" field Some excellent samples of coal have been obtained on this field, which will be served by the projected line from Chandil to Moghal Sarai

11 Without taking into account either the East Indian Railway Company's mines at Giridih, or the numerous small workings (mostly outcrops worked by individual native proprietors and whose output is—if of good quality—generally bought up by the larger colliery owners), the principal mines now being worked are owned by companies as shown in the following table —

OWNING COMPANY	NAME OF COLLIERY	COMPANY'S REPRESENTATIVE IN CALCUTTA
Bengal Coal Company	Kuldiah	C W Gray, Esq Supdt Bengal Coal Company Old Court House Street.
Ditto	Laikdee	Ditto ditto.
Ditto	Doonkoora	Ditto ditto
Ditto	Sanctoria	Ditto ditto
Ditto	Desherghur	Ditto ditto
Ditto	Sodepore	Ditto ditto
Ditto	Nimcha	Ditto ditto.
Ditto	Madhupur	Ditto ditto
Ditto	Raniganj	Ditto ditto

Note on Bengal Coal

Owning Company	Name of Colliery	Company's Representative in Calcutta
New Beerbhoom Coal Company	Borrea	Messrs. Balmer Lawrie & Co. 103 Clive Street.
Ditto	Belru	Ditto ditto
Ditto	Dhadka	Ditto ditto
Barákar Coal Company	Khama dobe	Messrs. Bird & Co 39 Strand
Ditto	Goorangdhi	Ditto ditto
Ditto	Loyabad	Ditto ditto
Ditto	Garoo	Ditto ditto
Ditto	Several workings on the Begunia seam near Barákar owned by small proprietors the out put from which is taken by the Barákar Coal Company	Ditto ditto
Borrea Coal Company	Rampore	F W Heilgers & Co 136 Canning Street
Ditto	Salanpore	Ditto ditto
Ditto	Shibdaspur	Ditto ditto
Equitable Coal Company	Desherghur	Messrs Macneill & Co 2 Clive Ghat Street
Ditto	Lachipur	Ditto ditto
Damudar Coal Company	Bharatchak	Messrs Gordon Stewart & Co. 4 Hare Street
Ditto	Bamandiha	Ditto ditto
Ditto	Gusik	Ditto ditto
Ditto	Lachipur	Ditto ditto
Bengal Nagpur Coal Company	Gangatia	Messrs Finlay Muir & Co Canning Street
Ditto	Bhuggutbee	Ditto ditto
Raniganj Coal Association	Bhooradih	Messrs Kilburn & Co Fairlie Place.
Ditto	Jotjanak	Ditto ditto
Ditto	Jamgram	Ditto ditto.
Ditto	Kastore	Ditto ditto
Adjai Coal Company	Nund	Andrew Yule & Co Clive Row
Katras Jherria Coal Company	Seebpore	Ditto ditto.
Ditto	Katras	Ditto ditto
East Indian Coal Company	Kendewadih	Jardine Skinner & Co. Clive Row
Ditto	Khoria	Ditto ditto.
Ditto	Brahminbararee	Ditto ditto
Ditto	Gopalpore	Ditto ditto.
Ditto	Mahatadish	Ditto ditto.
Ditto	Birsinpore	Ditto ditto.
South Barákar Coal Company	Patlabari	Gladstone Wyllie & Co 101 Clive Street.
Barabon Coal Company	Baraboni	Ram Chunder Bannerjee
Private Colliery at	Sejoora	Owned by Messrs. Finlay Muir & Co.

Note on Bengal Coal.

on this field is of an anthracitic description, and is, as a rule, of only second quality large quantity of very poor and dirty coal obtained from mines on this field has lately b exported from Calcutta under the name of "Borrea" coal, with the result that "Borre coal has now a bad name in the market But while all "Borrea" coal is thus condemn there is much of it, obtained from the "Borrea" seam, which is of very fair quality

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9 In the Jherria field there are some seventeen seams, the best coal being obtain from those known as "No. 12,' "No 13" and "No 15" The majority of the coal n being put on the market is of good quality, and like the Sanctoria coal contains a lar quantity of volatile matter.

10 The chief prospective coal field in Bengal is that known as the "Palamau," l sometimes spoken of as the "Daltonganj" field Some excellent samples of coal have be obtained on this field, which will be served by the projected line from Chandil to Mogl Sarai

11 Without taking into account either the East Indian Railway Company's mi at Giridih, or the numerous small workings (mostly outcrops worked by individual nati proprietors and whose output is—if of good quality—generally bought up by the larg colliery owners), the principal mines now being worked are owned by companies as sho in the following table —

OWNING COMPANY	NAME OF COLLIERY	COMPANY'S REPRESENTATIVE I CALCUTTA.
Bengal Coal Company	Kuldiah	C W Gray Esq Supdt. Ben Coal Company, Old Court Ho Street.
Ditto	Lakdee	Ditto ditto.
Ditto	Doonkoora	Ditto ditto
Ditto	Sanctoria	Ditto ditto
Ditto	Desherghur	Ditto ditto
Ditto	Sodepore	Ditto ditto
Ditto	Nimcha	Ditto ditto.
Ditto	Madhupur	Ditto ditto
Ditto	Raniganj	Ditto ditto

Note on Bengal Coal

OWNING COMPANY	NAME OF COLLIERY	COMPANY'S REPRESENTATIVE IN CALCUTTA
New Beerbhoom Coal Company	Borrea	Messrs Balmer Lawrie & Co 103 Clive Street
Ditto	Belu	Ditto ditto
Ditto	Dhadka	Ditto ditto
Barákar Coal Company	Khamardobe	Messrs Bird & Co 39 Strand
Ditto	Goorangdhi	Ditto ditto
Ditto	Loyabad	Ditto ditto
Ditto	Garooi	Ditto ditto
Ditto	Several workings on the Begunia seam near Barákar owned by small proprietors the output from which is taken by the Barákar Coal Company	Ditto ditto
Borrea Coal Company	Rampore	F W Heilgers & Co. 136 Canning Street
Ditto	Salanpore	Ditto ditto
Ditto	Shibdaspur	Ditto ditto
Equitable Coal Company	Desherghur	Messrs Macneill & Co 2 Clive Ghat Street
Ditto	Lachipur	Ditto ditto
Damudar Coal Company	Bharatchak	Messrs Gordon Stewart & Co. 4 Hare Street.
Ditto	Bamandiha	Ditto ditto
Ditto	Gusik	Ditto ditto
Ditto	Lachipur	Ditto ditto
Bengal Nagpur Coal Company	Gangatia	Messrs Finlay Muir & Co Canning Street
Ditto	Bhuggutbee	Ditto ditto
Raniganj Coal Association	Bhooradih	Messrs Kilburn & Co Fairlie Place.
Ditto	Jotjanak	Ditto ditto
Ditto	Jamgram	Ditto ditto
Ditto	Kastore	Ditto ditto
Adjai Coal Company	Nundi	Andrew Yule & Co Clive Row
Katras Jherria Coal Company	Seebpore	Ditto ditto.
Ditto	Katras	Ditto ditto
East Indian Coal Company	Kendewadih	Jardine Skinner & Co Clive Row
Ditto	Khoria	Ditto ditto.
Ditto	Brahminbararee	Ditto ditto
Ditto	Gopalpore	Ditto ditto
Ditto	Mahatadish	Ditto ditto
Ditto	Birsinpore	Ditto ditto.
South Barákar Coal Company	Patlabari	Gladstone, Wyllie & Co 101 Clive Street
Barabon Coal Company	Barabon	Ram Chunder Bannerjee.
Private Colliery at	Sejoora	Owned by Messrs. Finlay Muir & Co.

Note on Bengal Coal

12 In the following table I give as fully as I am able, information regarding the output of some of the best mines —

Name of Mine	Owning Company	On what Coal field	No on Map	Best Seams	Average Monthly Output in Tons	REMARKS
Kuldiah	Bengal Coal Company	Karharba	1	Lower Karharbár	12 000	
Laikdee	Ditto	Barakar	2	Laikdee	5 000	
Sanctoria	Ditto	Sanctoria	4	Sanctoria	1 500	Most of this coal taken for gas works
Desherghur	Ditto	Ditto	5	Desherghur	6 500	
Sodepore	Ditto	Ditto	6		4 000	Good locomotive coal but gives off heavy smoke
Madhubpur	Ditto	Raniganj	8		2 000	
Raniganj	Ditto	Ditto	9		3 000	
Borrea	New Beerbhoom Coal Company	Borrea	10		12 000	
Belru	Ditto	Sanctoria	11		2 000	
Dhadka	Ditto	Raniganj	12		3 500	
Khamardobie	Barákar Coal Company	Barakar	13	Khamardobie	5 000	
Goorangdh	Ditto	Raniganj	14	5 foot seam	10 000	
Loyabad	Ditto	Jherria			5 000	
Rampore	Borrea Coal Company	Borrea	17	Lower part of Borrea	1 500	
Salanpur	Ditto	Ditto	18 }	Ditto	5 000	
Shibdaspur	Ditto	Ditto	19 }			
Desherghur	Equitable Coal Company	Sanctoria	20	Sanctoria and Desherghur	10 000	The whole of the output of this mine is taken by Messrs Mackinnon Mackenzie and Co.
Lachipur	Ditto	Ditto	21	Lachipur	5 000	
Bharatchak	Damuda Coal Company	Ditto	22	Bharatchak	3 000	
Bamandiha	Ditto	Ditto	23	Bamandiha	2 500	
Gusick	Ditto	Raniganj	24		2 500	
Lachipur	Ditto	Sanctoria	25	Bamandiha	2 500	
Gangatia	Bengal Nagpur Coal Company	Ditto	26	Sanctoria	3 000	
Bhuggutbee	Ditto	Jherria	27	Nos 11 & 12*	5 500	* For locomotive purposes No 10.
Bhooriadih	Raniganj Coal Association	Karharbari	28	Lower Karharbari	6 000	Mine nearly worked out.
Jotjának	Ditto	Raniganj	29	Upper Damuda	4 000	
Jamgram	Ditto	Ditto	30	15 foot seam	1 000	

Note on Bengal Coal.

Name of Mine.	Owning Company	On what Coal field	No on Map	Best Seams	Average Monthly Output in Tons	REMARKS
Nundi	Adjai Coal Company	Raniganj	31		2 500	
Seebpore	Khatras Jherria Coal Company	Ditto	32		5 000	
Katras	Ditto	Jherria	39		5 000	
Kendewadih	East Indian Coal Company	Ditto				
Khor a	Ditto	Ditto			6 000	
Brahminbararee	Ditto	Ditto	33			New mines
Gopalpore	Ditto	Raniganj	34		2 000	
Sejoorah	Messrs Finlay, Muir & Co.	Jherria	36	No 10	5 000	
Baraboni	Baraboni Coal Company	Raniganj	37			
Patlabari	South Barákar Coal Company	Barákar	38	B seam	5 000	

13 Guided by information given to me by the several railway companies who have had experience with the different coals and others who are in a position to express an opinion in the matter, I am able to select and place in the order shown in the following table some of the coals which are known to be suitable for locomotive purposes* —

Order of Merit	From which Mine obtained	Colliery Owner	REMARKS
1st	Kuldiah	Bengal Coal Company	Karharbari coal
,,	Bhooriadih	Raniganj Coal Association	Ditto
2nd	Lakdee	Bengal Coal Company	Barákar coal
,,	Khamardobie	Barákar do	Ditto.
,,	Begunia		Barákar coal. There are several mines bearing this name which are being worked by private parties but the Barákar Coal Company command most of the output from the Begunia seam
3rd	Desherghur	Bengal Coal Company	Desherghur coal
,,	Ditto	Equitable Coal Company	Ditto The whole of the output of this mine is now taken by Messrs Mackinnon, Mackenzie & Co
4th	Gangatia	Bengal Nagpur Coal Company	Sanctoria coal
,,	Sodepore	Bengal Coal Company	Ditto.
,,	Lachipur	Equitable Coal Company	Ditto.
,,	Ditto	Damuda Coal Company.	Ditto
,,	Bamandiha	Ditto	Ditto
,,	Belru	New Beerbhoom Coal Company	

* East Indian Railway Company's mines not included.

Note on Bengal Coal.

Order of Merit.	From which Mine obtained	Colliery Owner	REMARKS
5th	Nundi . .	Adjai Coal Company	Good Raniganj coal
"	Seebpore .	Katras Jherria Coal Company	Ditto
"	Baraboni . .	Baraboni Coal Company	Ditto.
6th	Goorangdhi .	Barákar Coal Company	Ditto

14 Any of the above mentioned coals would, I think, be found to mix well together, and I have no doubt that they might also be mixed with Singareni coal to the improvement of the latter fuel

15 The Bengal coals now being used by different railway companies on their engines are as shown below —

Name of Railway	Description of coal being used.
Bengal-Nagpur . . .	Sodepore
Bengal-North-Western .	Karharbári
Bombay Baroda . . .	Borrea, Goorangdhi
Burmah	Borrea
East Indian . . .	Karharbári
Eastern Bengal .	Khamardobie, Goorangdhi
Great Indian Peninsula . .	Sanctoria (delivered at Nagpur)
Jodhpur	Karharbári
North-Western . . .	Goorangdhi, Khamardobie Karharbári
Oudh and Rohilkhand . .	Karharbári.
Rohilkhand and Kumaon . .	Karharbári
Rajputana-Malwa . . .	Karharbári.

16 Most of the better class Bengal coals may be said to be fairly good smithy coals, but in selecting for this purpose preference should be given to a sound, hard coal which will bear transport, and in the following list I name those coals which I think would be found most satisfactory —

Karharbári coal—From any of the mines working this coal, and that known as "smithy" coal from the East Indian Railway Company's colliery
Barákar coal—From the Laikdee, Khamardobie or Begunia mines.
Desherghur coal—From any of the mines working the Desherghur seam
Sanctoria—From any of the mines working the Sanctoria seam
Borrea coal—From the New Beerbhoom Coal Company's Borrea mine and the best coal from the Rampore Salanpur or Shibdaspur mines
Raniganj—Best coal from the Goorangdhi Nundi Seebpore or Baraboni mines

17 In the above list I have included "smithy coal from the East Indian Railway Company's pits, because it was explained to me by the colliery manager, that, although

not allowed by Government to supply steam coal to any one but the Locomotive Superintendent of the East Indian Railway, there is no objection to his supplying other railways and private parties with small coal The "smithy" coal in question is of good quality, and the rate at which it is at present being sold is Rs 2 8 per ton The price to be charged for the coal raised at the East Indian Railway Company's mines is revised and sanctioned by Government each half year In all probability the price of "smithy" coal for the half year commencing 1st July 1895 will be Rs 3 per ton

18 Except in the case of Karharbari "smithy" coal from the East Indian Railway Company's colliery, I think it would not be advisable to take any but steam coal for smithy purposes The East Indian Railway "smithy" coal would, I think, give satisfaction but if other coals are tried, I do not recommend the acceptance of small stuff known as "Mill rubble" and Brick burning rubble "

19 Foundry coke of apparently fair quality is manufactured at several of the larger collieries and that made at the East Indian Railway Company's colliery at Giridih and the Bengal Coal Company's colliery at Sanctoria is used in the railway shops at Jamalpur and Lahore respectively It may, later on, be possible to get supplies of Bengal coke which—although not of the same good quality as that which the Company now get from England—it may be an economy to use at Perambur, but at present there is none in the market

20 The average normal price of Bengal coke is about Rs 8 per ton at place of manufacture, and the cost of bagging it would be about Rs 5-8 per ton *

21 Within the last two years a great impetus has been given to the Bengal coal industry, owing to the increased demand for Indian coal, consequent on its good qualities being made more generally known during the late coal strikes in England The Peninsular and Oriental and the British India Steam Navigation Companies, as well as most of the other shipping companies whose steamers ply to and from Calcutta, are now large consumers of Bengal coal, and many mills in the Bombay Presidency, as well as the railway companies working to ports on the west coast of India, have, since the difficulty of getting cheap English coal arose, been in the market for Calcutta seaborne coal

22 Until within the last few months it was a question of finding a market for the comparatively speaking little coal raised at the different mines, now the question is how to obtain the coal quickly enough to meet the demand for it.

23 Railway companies are being pressed to complete projected lines which will open up new and extensive tracts of country known to be rich in coal of as good, if not better quality than the best at present being worked, the existing collieries are quite unable to cope with the demands made on them, and coal which twelve months back was sold at the pit's mouth for between two and four rupees per ton is now being paid for at the rate of between five and seven rupees a ton

24 The want of labour, and the absence of better facilities for transport, appear to be the chief causes interfering with more extensive working in the already opened up districts

25 There is a general complaint that the East Indian Railway Company is unable to supply wagons as quickly as required, and I understand that it is as much as that Company is able to do to find engine power to meet the requirements of the traffic between

* One hundred bags at Rs 20, and 27 bags to a ton of coke.

the mines and Calcutta Many colliery managers are also complaining of the delays that arise in the matter of putting down additional sidings at the mines

26 The recent large export business has not, however, been an altogether unqualified advantage to the reputation of Bengal coal To meet the orders of customers, inferior coal has been shipped under the name of some coal of known good quality In some cases a coal company under contract to supply a large quantity has purchased and included in their deliveries coals obtained from mines other than their own It does not necessarily follow that the coal thus obtained was inferior to that worked out of their own pits, but it would probably be of a different description to that contracted for In other cases colliery proprietors have in their first dealings with a customer, supplied coal of better quality than was being taken out of their own pits, and having obtained an order on the reputation of the sample submitted, have then completed their deliveries from their own mines

27 Advantage has been taken of the various ways in which a name can be applied to a coal Thus a coal of poor quality collected from some small surface working and put on to the railway at Barakar station has been allowed to bear the name 'Barakar,' a title which, as explained in paragraph 2 is legimately applicable only to coal of a particular nature or a coal which though of an inferior description and obtained on other than the Barakar field but of Barákar formation (*i e* cobbley) has been sold as 'Barakar coal Again a refuse coal, which in the first place has been sold by the Barakar coal Company from any of their workings (some of their pits are many miles away from Barakar and have no Barakar coal in them) has also been passed into the market as Barakar coal * In the same way the names "Sanctoria," 'Desherghur, 'Damuda, etc, hav often been knowingly misapplied to the disadvantage of the purchaser

28 Further, when as has lately been the case, there has been a sudden demand for coal, some collieries have I am afraid, not been over particular in the matter of separating their good from inferior coal One constantly hears it jokingly remarked that at present anything black will sell as coal' and that most of the mines are now turning out '*only* 100 per cent of steam coal" As a matter of fact little screening is being done at any of the mines and it is quite open to question whether old pit brow refuse does not sometimes find its way into the railway trucks

29 In this way some very poor coal has been exported to Bombay and it is not surprising that as is the case, Bengal coal is there condemned as an inferior and very dirty locomotive fuel

30 The only excuse for this style of working is that agents and colliery managers are being pressed to supply beyond their resources and purchasers are often willing to accept what they can get, rather than take the alternate of going without altogether

31 It is possible that the lately formed 'Indian Mining Association or some other corporation of those interested in the success of the Bengal coal trade, will be able to see their way to introducing some check on the discreditable way in which much of the business is carried on by petty contractors and agents but in the meantime the only safeguard for purchasers, who are not on the spot, is to refrain from doing business with any but coal companies or agents of well known good repute

32 Speaking without a very intimate knowledge of the subject, it seems to me that coal mining in Bengal has as yet hardly advanced beyond the speculative stage of

* The terms "Barakar *proper* and Barákar *district*' which have occasionally been quoted on the Madras Railway are terms invented by middlemen for their own purposes and have no real significance in the Bengal coal market.

development Most of the mines are not well equipped, and in nearly all cases it would seem as though the *system of working was a hand to-mouth one. It is not until* an order for a supply of coal is received that earnest work is done, and little, if any, coal is raised or new workings commenced in anticipation of orders. The consequence is, that when, as at present, there is a large purchasing market, the collieries are unable to supply, owing to absence of proper development and want of organised labour

33 The difficulty of obtaining, or rather I should say, the difficulty of retaining, good labour at the mines is without doubt a matter of much concern to many of the colliery proprietors The natives of the district are an independent and improvident class, and it is difficult to persuade them to earn more than a bare subsistence. As a rule a higher rate of wages means with them fewer hours of work, so that an increased rate of pay does not necessarily lead to a larger output of coal The harvests during the last two years have been exceptionally good, and food being cheap, the natives are now more indifferent and independent than usual.

34 But as an example of what can be done in the matter of overcoming the difficulty of getting steady labour, it is only necessary to look at those collieries worked on a system such as that adopted at the East Indian Railway and Bengal Coal Company's workings, where as large Zemindaries, the companies encourage their people to settle near their work and take advantage of rules introduced for their comfort and welfare The serious trouble which so cripples many of the Bengal collieries has been entirely overcome at Giridih, and it has been possible to largely increase the number of labourers at the East Indian Railway Company's pits, within the last three years without enhancing the rate of wages

35 *There is, I think, no doubt that when, as seems now to be probable, the better* class collieries can look to steady working, and things are done in a more systematic way the labour difficulty will become a thing of the past. At present, however, it is one of the great impediments to the more successful working of the mines, and is one of the causes for the present high price of Bengal coal.

36 Under normal conditions the estimated average cost of colliery working in Bengal, for mines served by Railway, may be taken at—

	Rs.	A.
Cutting and bringing to surface and loading into railway trucks, per ton	1	2
Royalty, per ton	0	7
Charge to capital on account of expenditure on workings of no intrinsic value, per ton	0	2
Cost of establishment, per ton	0	2
Depreciation of machinery and tools, per ton	0	2
Contingencies, per ton	0	1
Total per ton in railway truck	2	0

At present the labour charges are high, and the price now paid by purchasers for coal, loaded into wagons at the pit's mouth, is from Rs 5 to Rs 7 per ton

37 Nearly all the coal raised on the Karharbari field is despatched in a westerly direction for use on different railways, and most of the coal raised on the Raniganj field is used locally, but coals from other districts are now being largely exported from Calcutta

38 The East Indian Railway Company have running powers over the Eastern Bengal State Railway, between Naihati and Calcutta, and over the Port Commissioners' lines at Calcutta, and coal is trained from the mines to shipping depôts on either the Calcutta or

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Howrah side of the river Hooghly as required I attach to this report a sketch map showing the lines of railway referred to, Plate LXXVI

39 For the purpose of calculating the rates for carriage of coal the Railway Companies consider all Calcutta and Howrah shipping depôts as being the same distance from Hooghly, and in the table given in para 40 Calcutta includes all such depôts The rates for carriage of large consignments of through booked coal and coke to Calcutta are the same on the East Indian and Bengal Nagpur Railways and quoting from the last published Goods Tariff the rules which apply to coal exported in large quantity are the following —

"SECTION 111—*Rates for charge* —In consignments of 3 000 maunds and over For a distance up to 400 miles inclusive 0 15 pie per maund per mile

A terminal charge of 2 pies per maund in addition is levied in the case of coke and patent fuel booked to Howrah Sealdah and *via* and Chitpore and *via* *

SECTION 112—At the end of any calendar half year a consignee whose aggregate consignments received at one station during the half year shall have exceeded 50 000 maunds may claim a refund in respect of the payments made in accordance with the following scale For the purposes of this rebate all Calcutta stations to be regarded as one with Howrah —

On quantities in excess of—		Rebate
50 000 up to 200 000 maunds		2½ per cent
200 000	400 000	5
400 000	600 000	7½
600 000 ,,	800 000	10
800 000		15 ,,

the rebate under this scale will be limited to 10 per cent of the total quantity carried

SECTION 113—An additional rebate to that granted under Section 112 and calculated on the same scale will be allowed on the whole quantity of coal exported by one consignee by sea from Howrah or Calcutta as shown by the bills of lading but not including bunker coal This additional rebate will be limited to 10 per cent of the total quantity *exported*

Thus the maximum rebate claimable on exported coal will be 10 per cent in accordance with Section 112 and 10 per cent in accordance with Section 113 or 20 per cent altogether

40 The following table shows the cost of carriage of consignments of over 3 000 maunds of coal from some of the principal coal receiving stations to Calcutta —

STATION	RATE					
	Per maund			Per ton †		
	Rs	A	P	Rs	A	P
Rániganj	0	1	6	2	8	10
Asansól	0	1	8	2	13	4
Sanctoria	0	1	10	3	1	10
Sitarámpur	0	1	9	2	15	7
Barákar	0	1	9	2	15	7
Kaloobathan	0	1	11	3	4	2
Purdhunkhoota	0	2	0	3	6	5
Dhanbad	0	2	1	3	8	8
Katrasgarh	0	2	3	3	13	3
Giridih	0	2	7	4	6	3

An additional mileage charge—with a minimum of one mile—is made for all coal worked out of coal company's sidings

* The stations named are Calcutta depôts

† Maunds × 27 22

41 In reply to my enquiry as to whether the Madras Railway Company might hope to have a special rate quoted to them if they were in the market for large quantities of Bengal coal the Agent of the East Indian Railway advised me that there was no chance of his Company being able to see their way to giving any concessions beyond those now made to large exporters It was stated that, although the quantity of coal now being carried over the East Indian Railway is large, the profits to the Company are—owing to the cheap rates—only small, and that any further reductions could not be thought of at present

42 I was informed that the East Indian Railway Company are anxious that the Great Indian Peninsula Railway Company should co operate with them in view to the *introduction of a low through rate for coal carried to Bombay from the Bengal collieries*, but that the Great Indian Peninsula Railway Company are not disposed to fall in with the proposal

43 The East Indian Railway have also under consideration an arrangement by which coal could be booked through by rail and steamer from a coal-receiving station in Bengal to any Indian coast port at which the regular trading steamers are in the habit of calling Other merchandise is now dealt with in this way, and it is hoped that the steamer companies will be able to see their way to extending the arrangement, so as to include coal and coke

44 As yet there are not any modern appliances in the way of machinery for the loading of sea going vessels with coal at Calcutta, and at present all such work is done by hand.

45 When a steamer is berthed in the docks near to a line of railway, most of the coal is carried direct from the railway trucks to the vessel, but it often happens that, in order to release wagons, the coal has to be temporarily deposited on the dock sill All work done inside the docks is performed by labourers employed by the Calcutta Port Commissioners Shippers are not allowed to employ their own labour, and the charge for transhipping coal from wagons to ship is 8 annas per ton In the case of a tween deck steamer, it is considered good work if between 800 and 1,000 tons of coal is put on board per diem

46 The British India Steam Navigation Company have a river pier of their own at Bracebridge Hall on the Calcutta side of the river One steamer at a time can moor alongside of this jetty, and railway wagons are run near the receiving vessel, the loading being done in the same way as in the docks

47 At Shalimar, on the Howrah side of the river, several of the coal companies have plots of ground, which they rent from the Port Commissioners, on which coal is deposited prior to transhipment by lighters to steamers The East Indian Raiwlay have a line to Shalimar from Howrah, but comparatively speaking only little coal is brought to this depôt

48 Most of the export coal is shipped either at the docks or at the British India Steam Navigation Company s wharf, but much is brought by rail to the East Indian Railway Company's depôt at Howrah, and transported thence to steamers by lighters, which carry on an average 25 tons each At this depôt there are three stagings with shoots on which hopper wagons can be run out and their contents dropped direct into lighters moored alongside, but as most of the coal is received in ordinary wagons with side doors, this arrangement is useful only to a limited extent It often happens that owing to the crowded state of the yard, it is not possible to get the hopper wagons into position for running on to the stages and another drawback to the more extensive use

of the shoots, is that lighters cannot always moor at the stages At high tide the boats cannot be placed below the shoots, and at low tide there is not sufficient water to allow of the boats being floated to the stages

49 Most of the coal received at the East Indian Company s depôt at Howrah is first unloaded on to the ground and afterwards carried in baskets to lighters, which take it to the receiving steamer Much of the coal has to be carried over 300 yards, and on the occasion of my visit nearly all available space was occupied with some thousands of tons of coal of all description The many heaps were in close proximity to each other and I should not be surprised to learn that those supervising the work of loading up lighters sometimes make a mistake (?) and take coal from a heap of poor quality and get it mixed up with coal of a better description The railway company charge ground rent for coal depositing plots in their Howrah depôt and accordingly as the plots are near to or far from the wharfs the charges vary from Rs 5 to Rs 20 per mensem for each plot of 1 000 square feet

50 The approximate cost of transporting coal from railway wagons— received at either Howrah or Shalimar—to steamers may be taken at annas 12 to annas 14 per ton including hire of lighters

51 Many schemes for the better working of coal cargoes are under consideration, but so far those interested have not been able to agree as to what should be done The chief causes which would appear to stand in the way of the introduction of means for direct and rapid loading are—

(a) Want of confidence on the part of colliery proprietors as to their ability to supply in large enough consignments
(b) Doubt as to the ability of railway companies to supply a large number of wagons at some particular colliery at short notice.
(c) The majority of the steamers trading to Calcutta having their decks so arranged that a lot of trimming has to be done when a cargo of coal is put on board
(d) If a coal loading wharf with modern appliances is built on the river much work would be taken from the docks and the Port Commissioners would be losers thereby

52 The most advanced scheme is that proposed by the East Indian Railway Company which is to construct a branch line of railway taking off from their main line near Bally and leading to a coal wharf to be built on the Howrah side of the river opposite to Garden Reach on which would be erected cranes for lifting and tilting wagons over the hatchways of vessels All plans and estimates have been drawn up, and I understand that the work and expenditure has received the approval of the Company s Board of Directors The total estimated expenditure amounts to some 15 lakhs of rupees but as the mercantile community do not press the matter, and the Port Commissioners are naturally not in favour of it it is considered very doubtful whether Government will accord their sanction to the scheme There appears to be a strong feeling against the construction of the proposed line from Bally as it is thought that, if the line is made, it may interfere with the entrance of the Bengal Nagpur Railway in to Calcutta It would seem that the general feeling amongst merchants is that it would be a good thing for the trade of the port if another railway company were to work into Calcutta and with this in view they do not look with favour on any scheme which may in any way interfere with the proposed extension of the Bengal Nagpur Railway

53 It is thought that the Calcutta Port Commissioners would probably consider it worth their while to erect suitable appliances for the direct loading of coal carrying steamers if there were more steamers of the collier class trading to the port As it is nearly all steamers which now ply to and from Calcutta are fitted with several decks

arranged for the sto vage of general cargoes and owing to the amount of trimming that has to be done when they carry a full bulk cargo, these vessels could not be loaded with such quick despatch as to warrant the putting down of the shore arrangements required for the rapid and direct loading of coal

54 As I explain further on in this report, it is probable that ere very long there will be many collier class steamers trading from Calcutta and it can I think be only a short time before proper facilities for dealing with export coal are introduced at that port

55 It sometimes happens that large steamers which have to leave Calcutta on a neap tide have to complete their loading after having passed over banks which obstruct their passage down the river several miles below Calcutta City, so that in some cases, even with the best appliances for quick loading at the docks or elsewhere near Calcutta it will occasionally be necessary for part of a coal cargo to be transferred to a steamer by means of lighters

56 The question of converting Diamond Harbour into a port suitable for large ocean-going steamers was very thoroughly considered some ten years back, before the Kidderpore docks were sanctioned, and, although many of those consulted were in favour of the building of docks at Diamond Harbour the scheme did not meet with general approval, and was subsequently abandoned The Eastern Bengal Railway Company and the Agents of the British India Steam Navigation Company have since taken up the question of the construction of a river pier for direct loading of large steamers at this place but decided that such an arrangement was not practicable

57 The quantity of coal exported from Calcutta during the last ten years has been—

—		FOREIGN TRADE INCLUDING CEYLON	COASTING TRADE INCLUDING BURMA	TOTAL.
		Tons.	Tons	Tons
Twelve months ending 31st March	1886	500	2 186	2 686
Do	1887	159	1 570	1 729
Do	1888	300	1 638	1 938
Do.	1889	15 642	41 145	56 787
Do	1890	39 957	53 052	93 099
Do	1891	26 207	105 721	131 928
Do	1892	4 3 8	123 087	127,445
Do	1893	15 620	195 760	221,380
Do.	1894	51 125	246,456	297 581
From 1st April 1894 to 28th Feby	1895	57 077	177 390	234,467

58 The principal shipping firms in Calcutta are —

Company's own Superintendent	agent for the Peninsular and Oriental Steam Navigation Co	
Messrs Mackinnon Mackenzie and Co	do.	British India Steam Navigation Co.
„ Turner Morrison and Co	do.	Asiatic Line of Steamers.
Gladstone Wyllie and Co,	do	City do
„ Finlay Muir and Co.,	do	Clan do.
„ Graham and Co.	do.	Anchor and Hansa Line of Steamers
„ Hoare Miller and Co.	do	Harrison Line of Steamers.
„ Duncan Bros.	do	Mutual do.
„ Simpson and Co.	do	Calcutta Landing and Shipping Co.

The British India Steam Navigation and the Asiatic Companies have a regular service of steamers to Indian ports The other steamer lines do not participate in the regular coast trade, but with the exception of the agent of the Peninsular and Oriental Steam Navigation Company, the Calcutta agents of the respective companies are shipbrokers who do business on their own account Messrs Simpson and Company do a large business as landing and shipping agents and are prepared at all times to enter into a contract to load coal into steamers not lying in the docks

Note on Bengal Coal.

59 With the exception of a few small consignments for Bombay, the Peninsula and Oriental Steam Navigation Company have not hitherto carried coal for the public They have two steamers which have been fitted up specially for the coal carrying trade, but it is contemplated that these vessels will be fully engaged in carrying coal for the company's own use at their coaling stations in Ceylon India, and the Straits In reply to my enquiry as to whether it was probable that later on they would be in a position to carry under contract for the public, I was informed that there was not much likelihood of their doing so

60 The British India Steam Navigation Company have two steamers of the collier class now at work, and have four more such vessels under construction. These steamers will generally be engaged in carrying coal to the company's coaling depôts in the East, but the Agents anticipate being able to occasionally use them in conjunction with their regular steamers when large consignments of coal are being carried to different ports I understand that the company are likely to add to their fleet of coal carrying steamers as the Calcutta export coal trade increases The company state that they can undertake to deliver coal in stated quantities at stated times, but that if it is left to them to deliver as convenient to themselves, they will probably be able to see their way to reducing their charges The agents were unable to quote an approximate price at which they would be prepared to contract to carry regular supplies of coal

61 As well as being agents for the British India Steam Navigation Company, Messrs Mackinnon Mackenzie and Co are large dealers in coal, and they have directly a large interest in the coal producing business. Several of the best mines in Bengal are under contract to give them the whole or a large part of their output, and Messrs Mackinnon, Mackenzie and Co are prepared to take contracts for the supplies as well as delivery of coal With their own loading depôt and a large number of steamers always available, they are able to compete on very favourable grounds with others

62 The Asiatic Steam Navigation Company say that they have considered the question of having collier steamers to trade between Indian ports, but that they are not satisfied that it will pay to have that class of steamer They say that Rs 5 per ton is the lowest freight charge at which it can be expected that coal will ever be carried from Calcutta to Madras, and they give it as their opinion that without a return cargo, steamers could not work at as low a rate as this They are not prepared to enter into any agreement for carrying regular supplies of coal and say that at all times coal will have to give way to better paying merchandise I was advised that at times when there is a heavy grain traffic they will probably be unable to carry coal at all, and at other times the freight for coal will vary accordingly as there is much or little other merchandise to carry

63 The other shipping agents referred to in para 58 all stated that none of the regular steamers for which they are agents can be considered in connection with the question of coal carriage to Madras, but they all expressed their willingness to act on behalf of the Madras Railway Company, in the matter of either obtaining a suitable steamer on a time charter, or chartering vessels as required for single voyages These agents would further be glad to supervise work and make disbursements in Calcutta, should the railway company hire a steamer on a time charter, the rate of commission for such business to be a fixed rate per voyage, or a percentage on the tonnage carried, or on the payments made on behalf of the railway company

64 It would appear that ship owners have a dislike to trading with Madras Whether Madras has deservedly obtained for itself a bad name for other reasons, or whether it only shares in the prejudice which Calcutta firms have against all Indian east coast ports, at which the landing facilities are so bad, I am unable to say, but certain it is that ship owners and agents much prefer to trade with Colombo, Bombay, and other west coast ports rather than with Madras

Note on Bengal Coal

65 It is, however, I think generally recognised that the freight charges now being paid on coal exported from Calcutta to Madras are higher than they should be but it will not be until the monopoly which the regular lines have, is broken through, that any great improvement can be looked for in this respect

66 English built sailing ships and native craft cannot be considered in connection with the question of regular coal carriage from Calcutta to other Indian ports Insurance companies will not grant policies in the case of native ships and large sailing vessels cannot compete with steamers in the matter of short distance freight especially when, as at Calcutta there are heavy towage charges to be met A sailing ship would have to take in and discharge ballast through her hatchways each return trip, and the uncertainty as to the time that would be occupied between ports would interfere with any arrangement for regular working

67 Several of the large coal companies have lately been considering the question of establishing their own fleet of colliers but while they have been *thinking* the British India Steam Navigation Company has *acted*, and it is doubtful whether the coal companies will now venture to compete with Messrs Mackinnon, Mackenzie and Company in the coal carrying trade If the coal companies have their own steamers they *must* expect to have to work them back to Calcutta from the delivering port in water ballast, whereas the British India Steam Navigation Company, being an old established concern with shipping agents at most of the ports at which coal steamers would be required to call would often be able to get return cargoes to Calcutta and the coal companies are afraid that the British India Steam Navigation Company will be able to afford to always keep their freight charges for coal at such a figure as to successfully compete with any opposition steamers I am at liberty to state that the question of having their own fleet of colliers is still before one of the leading coal companies in Calcutta and another company state that in the event of their obtaining a contract for the regular supply of large quantities of coal they will arrange to hire a collier steamer on a time charter

68 Many coal steamers are now available for sale or hire in England but owners hope for a great improvement in the shipping business within the next few months and it is not likely that any vessel could be obtained on a time charter for longer than twelve months It is thought that a collier steamer could now be chartered for twelve months at a monthly rate equal to about Rs 4 per ton of carrying capacity With the present facilities for loading at Calcutta and discharging at Madras, such a steamer should be able to make fourteen or fifteen double voyages between Calcutta and Madras in a year

69 As an example of the terms on which such a vessel could be chartered I give below extracts from a Charter Party agreed to by a Calcutta firm during the month of March 1895 in the case of a steamer of ' 2 381 tons gross register or thereabouts of ' 1 526 tons net register or thereabouts, and of 300 H P or thereabouts ' hired on a time charter for six months —

> The captain states that steamer can lift 3 284 tons dead weight inclusive of coal and stores. The steamer to guarantee a speed of 9 knots per hour on a consumption of 16 tons Cardiff coal for 24 hours. * * * * * * * * * * * * *
> Owner shall provide and pay for all the provisions and wages of the captain, officers, engineers firemen and crew for the insurance of the vessel also for all engine room and other stores also for dunnage when necessary and shall maintain her under British colours and in a thoroughly efficient state for the service and in every way seaworthy in hull boilers machinery and equipment The charterer shall provide and pay for all the coals, fuel, mats, port charges pilotages agencies commissions and all other charges whatsoever except those before stated * * * * * * * * * Charterer shall pay for the use and hire of said vessel at the rate of R12 000 per calendar month * * * * Payment to be made in cash monthly in advance. * * * *

70. As a guide to the probable cost of working a time-chartered steamer between Calcutta and Madras, I quote below some notes kindly furnished to me by Mr Paterson of Messrs Hoare, Miller and Company with which I have embodied other information obtained from the Secretary of the Madras Harbour Trust —

Steamer to make round voyage to Madras in 24* days = 15*voyages in a year, carrying capacity say 3 250 tons each voyage and 250 tons in bunkers		
Freight at Rs 4† per ton a month on carrying capacity of the steamer "including bunkers = Rs 14 000 × 12	=	Rs 1,68 000
Cost of bunker coal —180 days steaming (15 voyages) = 20 tons a day = 3 600 tons coal at Rs 9‡	=	„ 32,400
Calcutta disbursements § say Rs 1,600 each voyage	=	„ 2 000
Agents' commission, As 4 per ton of freight	=	„ 12,187

Madras Disbursements

Pilotage fifteen voyages at Rs 34 per voyage	=	Rs. 510	
Port dues on net tonnage, say 1,800 tons for fifteen voyages = 27,000 tons at As 1¾ per ton	=	„ 2 953	= 3 463
			15) 2,40,050
Cost per voyage			Rs 16 003

or $\frac{\text{Rs } 16\,003}{3\,250}$ = Rs 4-14 6 cost per ton of cargo

71 The insurance rate quoted by Messrs Hoare, Miller and Co is ⅝ per cent.

72 Taking the figure Rs 4-14-6 (see para 70) as the cost at which a ton of coal can be carried from Calcutta to Madras, the following calculation gives the approximate cost of conveying a ton of coal from a mine near Sitarampur or Barakar railway station to the Madras Railway Locomotive yard at Royapuram —

	R	a	p
Railway freight to Calcutta	2	15	7
Transhipping from railway truck to steamer at Calcutta	0	12	0
Steamer carriage to Madras	4	14	6
Madras Harbour dues	0	12	0
Discharging at Madras ‖	1	15	0
Madras Harbour charge on railway trucks	0	2	0
Cost of conveying a ton of coal from mine to Royapuram yard	11	7	1

73 Accepting the above figure as approximately correct, it would appear that before Bengal coal can be put down in the Royapuram yard at the same price as that now paid for Singareni coal, *viz*, Rs 14 per ton, it must be obtainable at the pit s mouth at a price not exceeding Rs. 2 8-11 per ton But I consider that the charges dealt with in para 70 may be accepted at outside rates The cost of bunker coal would be the same as that paid for cargo coal, which must be cheaper than Rs 9 per ton before the Madras Railway Company can do business with the Bengal mines The Calcutta transhipping charges are taken at 12 annas per ton, but if—as would probably be the case—nearly all loading were done in the docks, the rate for this work would be only annas 8 per ton It is also probable that the rate of commission to be paid to a Calcutta agent could be arranged on more favourable terms for the company. It must also be remembered that the quality of the better

* Twenty-four days is probably a liberal estimate for a steamer of about 3,000 tons, *i e*, six days loading ten days to and from Madras, eight days discharging = 24 days "

† Freight could probably be now arranged at about Rs 4 per ton, and for a steamer of say 5,000 tons carrying capacity something less might be taken

‡ Taken at lowest price now ruling at Calcutta

§ Includes pilotage port dues mooring charges etc etc "

‖ Includes stevedores annas 5 boat hire and gunnies Rs 1 4-0 parterage annas 6 = Rs. 1 15-0 per ton

class Bengal coals is superior to that of Singareni coal, and I consider that when making a comparison, an allowance of at least 10 per cent should be added to the estimated price of Bengal coal I think, therefore, that it is quite possible that if the company were to charter their own steamer they would be able to afford to pay as much as from Rs 4 to Rs. 4 8-0 per ton for coal at the Bengal mines and yet put it down at Madras at less cost than the price at which Deccan coal is now supplied.

74 Twelve months back many contracts for the supply of good Bengal locomotive fuel were entered into by coal companies at a rate of about Rs 3-8 0 per ton delivered into wagons at the mines, and I think that under ordinary circumstances Rs 3 8-0 to Rs 4 may be taken as a fair average price for good Bengal coal The prohibitive price at which it is now being sold prevents its being used on the Madras Railway, but the general opinion seems to be that the high rates now ruling will give way to more normal prices within the next twelve months, and, if freight charges can be economically arranged, there does not appear to be any reason why in 1896, and until the East Coast Railway is opened between Bezwada and Madras,* seaborne Bengal coal should not successfully compete with Singareni coal on the Madras-Cuddapah district of the Madras Railway.

75. The different arrangements under which, it occurs to me, the business of receiving supplies of Bengal coal at Madras could be carried out are—

A —Coal company to contract to deliver f o b Madras
B —Commission agent in Calcutta to contract to deliver f o b Madras.
- (a) a stated quantity each month
- (b) a stated quantity within twelve months.

payment to be made
- (1) on weight as shown on railway way bills in Calcutta.
- (2) on actual weight as weighed into ship at Calcutta.
- (3) on actual weight as weighed out of ship at Madras.
- (4) on actual weight as taken on M. R weigh bridge

C —Coal company to contract to deliver f o b Calcutta a stated quantity on receipt of a certain number of days notice

payment to be made
- (c) on weight as shown on railway way bills
- (d) on actual weight as weighed into ship at Calcutta

and
- (5) railway company to have its own collier with agent to superintend business in Calcutta
- (6) railway to have agent in Calcutta who would charter on behalf of railway vessels for single voyage as required,

  the agent to receive commission
  - (m) at fixed rate per voyage
  - (n) at fixed rate on cargo tonnage dealt with
  - (p) on account of disbursements made on behalf of railway
- (7) agent in Calcutta to contract to carry to Madras

  and payment made
  - (q) on actual weight as weighed out of ship
  - (r) on actual weight as taken on M R weigh bridge

D.—Railway to have agent in Calcutta who would purchase on behalf of railway up to a maximum stated quantity within a [illegible] maximum rate

on to be [illegible]
- (c) on amount disbursed, the rate of commission increasing as the rate per ton of payments decreases of coal dealt
  - (8) as shown on railway way bills
  - (9) as weighed into ship at Calcutta
  - (10) as weighed out of ship at Madras
  - (11) as taken on M R weigh bridge

76. The question as to the procedure that should be adopted to ensure the receipt of full contract weight of coal, and at the same time avoid delays and inconvenience, is a

	R a. p.
Purchase rate per ton at mines	4 8 0
Tra nage, at 3 pies per ton per mile, from Yellandu to Madras—360 miles	5 10 0
TOTAL	10 2 0

difficult one to solve Railway companies and coal companies have not as yet been able to satisfactorily arrange matters between themselves, and there is no generally recognized method of dealing with ship's cargoes

77 In order to save delay and expense railway companies ask that the weight of consignments may be calculated on the cubical contents of wagons different allowances being made for different descriptions of coal, but in many cases this arrangement has been found to be unsatisfactory, and railway companies have put down weigh bridges for the purpose of weighing either all or a percentage of the wagons carrying a consignment, unless however, the coal is loaded directly into steamers railway weights, in whatever way arrived at, are not of much value to the purchaser

78 Suppliers naturally prefer to receive payment for their coal as delivered in Calcutta rather than wait for advice regarding the outturn at port of destination When tendering for contracts in which it is stipulated that payment is to be made on the weight as found on delivery at destination port, they invariably add a large percentage to the price at which they can undertake to deliver f o b Calcutta As a set off against wastage etc, they are willing to give an allowance of about 2½ per cent on invoice weight if Calcutta figures are accepted

79 The most complete way of dealing with a coal cargo is for it to be weighed into the ship at Calcutta for the satisfaction of the coal company, and weighed out of the ship at the port of destination for the satisfaction of the shipping agent and the purchaser

80 The Bengal Chamber of Commerce employ a staff of men known as "sworn measurers, and the Chamber undertake to weigh and grant certificates for coal as loaded into lighters or as put on boardship In the case of coal put on boardship direct from wagons, the Bengal Chamber of Commerce will also undertake to check, as far as possible, the railway way bills for the purpose of noting the name of the despatching station, but as explained in previous paragraphs of this report, this check is not sufficient to ensure the shipping of coal of the description and quality contracted for The charges that are made for the services of a sworn measurer are for consignments of coal or coke under 100 tons, annas 4 per ton, exceeding 100 tons, annas 3 per ton exceeding 200 tons, annas 2 per ton

81 An alternative means for checking the weight as well as the quality of coal shipped at Calcutta is for the purchaser to employ an inspector on his own account, but as such an inspector would necessarily have to be an expert judge of coal and would be required to give a lot of time at irregular intervals, to personal supervision of the work, and would, moreover, have to be a man above suspicion it is not to be expected that a really competent man would undertake the work except for a fairly high remuneration

82 Under present circumstances coal companies object to having to deal with shipping business, and if a coal company contracts to make deliveries at Madras, it is probable that unless they intend to have their own steamers, the rates quoted will be higher than the price that would have to be paid if the business were divided between a coal company who would deliver f o b Calcutta and a shipping agent who would arrange for the sea carriage of the coal When calling for tenders for supplies of coal the Burmah State Railway ask for alternative rates one for deliveries at Rangoon and one for deliveries f o b Calcutta At the same time they advertise for tenders for the carriage of their supplies from Calcutta to Rangoon, and I believe that, as a rule, the contract for the supply of coal is distinct from that entered into with the shipping contractor If the different coal companies have their own steamers, the difficulty of arranging for freight which now causes them to hesitate before entering into agreement to deliver ex ship, would no longer exist,

and being able to correctly estimate all charges, they would be in a better position than at present to tender for supplies delivered at Madras

83 I think that much might be done in the matter of reducing freight charges if other railway companies would co operate with the Madras Railway Company, and jointly place large orders with one concern If this were done, sufficient business might be placed in the hands of one coal company to make it worth their while to start collier steamers on their own account or obtain such vessels on time charters The order which the Madras Railway alone could give would not be a sufficient inducement for any firm to do this I understand that the South Indian Railway Company have already expressed their willingness to consider some such scheme, and from conversation which I had with the Locomotive Superintendent of the Bombay-Baroda Railway, I gathered that he would be glad to entertain proposals for an arrangement of the kind suggested The Locomotive Superintendent of the Great Indian Peninsula Railway is not disposed to favour the more extended use of Bengal coal on his line, but I beg to suggest that the Ceylon and Southern Mahratta Railway Companies be asked to give consideration to the question, and if the several railways mentioned were to co operate in the way proposed, I think it would be a step in the right direction towards the obtaining of *good* Bengal coal at a *cheap* rate

INDEX.

STEEL-TIRED WHEELS.

Report of the Committee of the Master Car-Builders' Association, dated Philadelphia, 24th May 1894

Your Committee has received replies to its circular of inquiry from 62 members representing 17,562 cars, or about 57 per cent. of the passenger, car equipment in the country. These members report 145,820 wheels under passenger equipment cars and that 51,862, or about 36 per cent. of them, are steel-tired wheels.

The following information has also been tabulated from these replies —

NUMBER OF STEEL-TIRED WHEELS IN USE OF EACH TYPE AND MAKE
ENGINE TRUCK AND TENDER WHEELS INCLUDED.

TYPE	MAKE.	NUMBER.	TOTALS.
Bolted Plate	Allen	13,943	
	Paige	7,369	
	Boies	1,898	
	Thurbur	144	
	Munton	50	
	Chicago Spring & Tire Co	50	
	Indefinite	9,095	32,549
Spoke	Arbel	3,200	
	Krupp	236	
	Paige	715	
	Boies	698	
	Brunswick	1,287	
	Vauclain	704	
	Owen & Dyson	8	
	Wednesbury	32	
	Cast Spoke (C. & A R R)	412	
	Cast Spoke (B. & M R. in Neb)	62	
	Plain Spoke (O & W. R. R.)	100	
	Indefinite	1,330	8,784

Steel-tired Wheels.

NUMBLR OF STEEL-TIRED WHEELS IN USE OF EACH TYPE AND MAKE.

ENGINE TRUCK AND TENDER WHEELS INCLUDED—*contd*

TYPE	MAKE	NUMBER.	TOTALS
Disk or Solid Plate	Allen	1,435	
	Arbel	18	
	Boies	244	
	Krupp	5,795	
	Washburn	1,681	
	Snow, Boltless	3,515	
	McKee, Fuller & Co	208	
	Fowler	259	
	Taylor Iron & Steel Co	100	
	Indefinite	418	
			17,673
Indefinite			8,600
	GRAND TOTAL	...	67,600

NOTE —Fifteen members reporting steel tired wheels failed to specify number, type or make, and therefore are not represented in the figures given in this statement.

DEFECTS DEVELOPED IN EACH TYPE OF WHEEL.

NUMBERS UNDER EACH ITEM INDICATE THE NUMBER OF MEMBERS REPORTING SUCH DEFECTS.

DEFECTS	Bolted plate	Spoke.	Disk or solid plate.
Loose tire	22	10	11
Loose hub	13	2	...
Loose bolts	37	1	1
Loose plates	22		...
Broken bolts	30	1	...
Burst tire	14	8	3
Burst or cracked hub	...	13	1
Broken or cracked plates	5	...	3
Bolt holes worn oblong	23	...	...
Burst or cracked solid disk centres	...	..	4

Steel-tired Wheels.

DEFECTS DEVELOPED IN EACH TYPE OF WHEEL.

NUMBERS UNDER EACH ITEM INDICATE THE NUMBER OF MEMBERS REPORTING SUCH DEFECTS—*contd.*

DEFECTS	Bolted plate	Spoke	Disk or solid plate.
Broken or cracked brackets on solid disk centres .		.	1
Broken or cracked spokes	.	10	...
Broken or cracked rims on spoke centres . . .	...	2	..
Rims of spoke centres flattened between spokes . .	...	...	...
Broken or cracked internal flange on tire . . .	3	..	...
Retaining ring broken or defective	2	3	5
TOTAL .	171	50	29

DEFECTS FIRST DEVELOPED IN EACH TYPE OF WHEEL

NUMBERS UNDER EACH ITEM INDICATE THE NUMBER OF MEMBERS REPORTING SUCH DEFECTS FIRST DEVELOPED

DEFECTS	Bolted plate	Spoke	Disk or solid plate
Loose tire	10	5	8
Loose hub	2	1	..
Loose bolts	31	1	...
Loose plates	9	...	1
Broken bolts	4	...	...
Cracked tire	3	...	...
Cracked plates	2	2	1
Cracked spokes	...	5	...
Loose rings	1	...	- 1

TYPE OF WHEEL FOUND TO GIVE MOST SATISFACTORY SERVICE

TYPE	MEMBERS REPORTING	
	Number	How many steel tired wheels in use
Bolted plate	16	25,335
Spoke	4	3,196
Disk or solid plate	15	15,363
Not given	27	23,706
TOTAL .	62	67,600

LIMIT OF THICKNESS FOR TIRES

It seems to be the consensus of opinion that one inch is the proper limit of thickness for tires On account, however, of the variety of sections of tires used, it is important that this limit be clearly defined and your Committee, therefore, offers the following recommendations

1 That the limit for thickness of tires of all steel-tired wheels shall be one inch measured normally to the tread and radially to the curved portions of the flange, through the thinnest part within 4½ inches from the back of the flange—the thickness from the latter point to outer edge of tread to be not less than one-half inch at thinnest part *See Plate LXXVII.*

2 That, in order to facilitate inspection, a small groove shall be cut on outer edge of all tires at a radius ½ inch less than that of the tread of tire when worn to the prescribed limit.

3 That the above recommendations shall be submitted to letter ballot for adoption, as "Recommended Practice" of the Association

Drawings, accompanied by notes containing information as to number of parts weights of principal parts and methods of manufacture and re-tiring, are submitted herewith, *See Plate LXXVII to LXXVII,* and include all makes and styles of steel tired wheels now in the market for which your Committee has succeeded in obtaining such information

Respectfully submitted,

R. E MARSHALL, *Chairman*
J. O PATTEE,
C H COPY,
A E MITCHELL,
H BARTLETT,
T. A BISSELL,
Committee

Discussion on steel tired wheels

MR WALLIS I move that the recommendation of the Committee be submitted to letter ballot

MR WAITT It seems to me it would be somewhat unfortunate to have the recommendation submitted to letter ballot in just the form that it is now I notice in looking over the different types of wheels that there are some types that would manifestly be dealt with unjustly if the recommendation of the Committee should be finally adopted. There are some types of wheels two types I see—the Washburn wheel and the McKee-Fuller wheel—where the tire and centre are in one piece, where the tire is supported solidly, so that it cannot be affected by expansion or contraction to take one part away from the other There are some members who can testify from a number of years of experience with some thousands of such wheels that they have found to run with perfect safety without any exception at all, or any failure at all, that they can run the tires down to half inch thick, and have never found a single case of a burst tire or cracked tire I will say that we do not use those wheels on our road, though I wish we did, so as to have an opportunity of gaining experience with them But it seems to me that in any standard that we adopt for the Association we ought to make it so that it will be just to all We do not want to throw out the tire of a wheel that is perfectly safe to run for a great many thousand miles more, simply because it is the misfortune of some of the wheel

makers to have their tires separate from the centres, so that the heat, when the brake shoe is applied, will expand the tire and not give a firm foundation on the centre I hope that if this is going to be submitted to letter ballot that it will provide for the two classes of wheels, one where the tire is solid with the centre, and the other where the tire is separate from the centre and is held by retaining rings or bolts I think Mr. Lentz and Mr Adams both have had experience with the type of wheels where the tire and the centre are practically welded together, and I wish that each of the gentlemen would give us his experience with the running of the tires down to less than one inch in thickness.

MR LENTZ I am sorry that I have not the data with me which might enable me to give the Association the benefit of our experience with the McKee-Fuller wheel But my recollection is that the present practice on our road is that we wear them down to five eighths of an inch

MR ADAMS I can say, Mr President, that Mr Lentz is perfectly safe in wearing the wheels down to five eighths of an inch We have used that type of wheel for twenty-five years, more or less, and probably have the largest number of that type of wheels in use, although we use different makes of steel wheels We have a good many Washburn and some Boies and a good many of the Brunswick wheels, as they are termed here and I see they make difference between the Brunswick and Wednesbury But the Brunswick wheels we have are all made at Wednesbury. We have about six hundred of them We have been accustomed to use the Washburn wheel, which is the type of wheel understood by all to be virtually a solid wheel The steel is fused on to the cast iron and we have run a great many of those wheels down to a quarter of an inch I may say that we do not consider that good policy, however For the last two or three years we have taken considerable pains to watch the working of those wheels and two years ago we used fifty per cent of the wheels that came out from the passenger service, where we thought we had used them as long as it would be safe and prudent to use them in passenger service and put them into freight, and they continued to run in freight, and we usually found that they would do the service then of about three or four cast iron wheels The last year there was about ninety per cent of them that went into freight The reason for that is that the general impress on all over the country is that steel wheels should not be used much less than an inch thick The consequence was we have not run them down so low, and we have taken them and put them right into freight service We cannot afford to throw away a wheel that will do five or six or eight years freight service and make it scrap We know that they will do this service in freight use after they have done two or three hundred thousand miles in passenger service We have had some broken wheels of the Washburn pattern it is true, but as I have stated to the convention two or three times, we never have had an accident resulting from one of those wheels in twenty five years They always showed the defect before any serious trouble resulted and we verily believe that they are as good a wheel as any We have been very fortunate with all our steel wheels We call them all good wheels I do not know that I have any special preference for one over another—a very great preference But I think from our experience we are rather led to the conclusion that the Washburn wheel is the cheapest wheel for the money It has done the most service for the money expended, and we can get so much more wear out of it by using it in freight service As to the wheels that are made up or shrunk on to the centre, it would not be a very safe thing to put them into freight service after they get down to three fourths of an inch or seven eighths of an inch perhaps If the track happened to be rough, or anything of that kind or they struck a frog, they would be liable, if they are so thin, to break the tire, while the wheel that is solid and has got a base to it is not subject to that liability My experience has been very favourable to the steel wheel and our wheel equipment is, and has been for nearly twenty years entirely steel We never put anything else under our passenger equipment or under

any of our engines Our president would not allow it He hardly would consent to allow a car to come on the road that did not have steel wheels Of course, we have to run them sometimes, but we object to them.

MR WAITT I move an amendment, which is that when this matter is submitted to letter ballot it be so modified as to provide for a thickness not less than five eighths of an inch in the case of wheels where the tire and centre are fused sold , but in the case of made up wheels it be as the Committee recommend

MR CASANAVE I second the amendment

MR MITCHELL *I would like to ask Mr. Adams if he uses the worn out McKee-Fuller* wheels to place under freight cars for interchange with foreign roads

MR ADAMS We never have used the McKee-Fuller wheel

MR MITCHELL The Washburn wheel, I should say

MR ADAMS We do not as a rule intend to put them under cars for interchange, because there have been objections to them The 33 inch wheel gets worn down so small that the objection I have heard brought against it—and it was the only objection—was that it was smaller than the other wheels while there is very little difference in the running of it But other roads would object to them and have taken them out sometimes when there was no occasion for it whatever, and we have lost some in that way, so that we have confined these wheels more particularly to cars that are retained on our own road such as flat cars and cars of that character that do not go away from home so much We have intended to place them there more than anywhere else, more for the purpose of keeping them in use than anything else When the 36 inch wheel, which is our standard wheel now, is worn down so thin that we would hardly keep it under passenger service, it is just about the right size for freight, and I have never heard an objection raised to that. The only objection I have ever heard brought against the wheel in freight cars was that it was smaller than the other wheels It would not be perhaps more than thirty inches, and they would take it out because it was smaller

I do not understand what the Committee desires in regard to the groove in outer face of tire I do not quite get the idea of it. I would like to hear that explained a little more fully.

MR MARSHALL The sections of tires of different wheels are so different that inspectors cannot correctly judge the thickness of the tire from the thickness at the edge. Some tires have more metal on the outer edge than they have at the centre and some have very much less The idea is to cut a groove on the outer face of tire a quarter of an inch below the condemning point, such groove to be cut when the wheels are made or when they are mounted by shopmen who will know the exact section of the tire

MR ADAMS You do not show that in your diagram

MR MARSHALL We tried to do so One fourth of an inch above that groove is the condemning point for any steel tire

MR GIBBS I would like to ask the Committee if in their replies any distinction was made on the tire thickness between wheels with the integral centre and the bolted centre That might guide us somewhat

MR MARSHALL There were very marked differences shown between the integral lock and the other methods of tire fastening They seemed to be governed principally

by the amount of metal that was cut away under the flange by the tire fastener and also by the amount of metal shown on the outer edge as compared with the amount in the body of the tire.

MR BUSH It does not seem to me quite right to adopt a limit such as proposed by Mr. Waitt, without further investigation, and I would like to propose a further amendment I would suggest that the report of the committee be received and printed and that the committee be continued another year with instructions to report on this distinction that has been brought up, and include it in the report

MR LEWIS It seems to me it is not just exactly the thing to establish an arbitrary limit for all forms and kinds of steel-tired wheels We know that a wheel that is shrunk on or held on to the centre by an ordinary retaining ring does not have the same strength that a tire has which has a supplementary flange to be bolted through the centre, similar to the Allen paper wheel or the Paige wheel Now we know that a tire of that form of construction will stand very much more than a plain tire without the supplementary ring, and it would seem that the Committee should submit the question according to the different types of wheels shown by them here as to what the limits should be, and not establish an arbitrary limit for all steel tired wheels, no matter what the design of the tire is

MR MITCHELL Regarding the question raised by Mr Lewis, as I understand the recommendation of the committee of which I was a member, it was that one inch should be the limit for interchange Several makes of wheels can be worn down less than one inch As I understand, this one inch governs only the interchange of cars from one road to another, and does not govern the action of any road as to the condemning point of steel-tired wheels on its own road

MR LENTZ I second the motion Mr Bush made

THE PRESIDENT Do you accept Mr Bush's amendment, Mr Wallis?

MR WALLIS *I do not.*

THE PRESIDENT Mr Secretary, will you read the amendment?

MR CLOUD I understand Mr Bush to propose that the motion be amended so that the Committee shall be continued another year to report further, making a distinction between the two classes of wheels, those which have the tire welded to the centre and those which do not

THE PRESIDENT As you understand, gentlemen, you vote now on Mr Bush's amendment to the original question

The amendment was lost

MR BARR Did we vote on the amendment to continue the Committee for another year?

THE PRESIDENT Yes

MR BARR I do not think that was understood

THE PRESIDENT We will take the vote over again if it was not understood. The Secretary will read the motion

MR CLOUD Moved to amend so as to continue the Committee another year, with instructions to report further and distinguish between the two classes of wheels, the one in which the tire is welded to the centre and the other in which the tire is not welded to the centre

This motion was put and carried

THE PRESIDENT The vote in the first place was taken on the amendment of Mr Bush, which was not accepted by Mr Wallis, who made the original motion That brings us back to the original motion so that we must take a vote on the original motion as first offered, as amended

MR LEWIS I would like to have you state what that motion is

MR CLOUD The amendment seems to take the place of the original motion, so that another vote will be on the question you have just carried which is Are you going to continue the Committee another year to make a distinction in limit between the wheels in which the centre is welded to the tire, and wheels where it is not so welded?

MR MARSHALL It seems to me, if this was referred back to the Committee, they could confer with the members who are specially interested, at the convention here, and report to the convention at the last day's session If it is in order I would offer that as an amendment to the motion that has been made, that it be referred to the committee to consider that question and put in shape

MR CASANAVE You would have to reconsider the motion just passed in order to do that, and that will be the simplest way to go about it. If it is recommitted to the committee to-day to be reported on to-morrow, they can get the report in shape to be acted upon

MR LENTZ I move that the resolution just passed be reconsidered

The motion to reconsider was carried.

MR CASANAVE I would move that the report be recommitted to the Committee to be reported back to-morrow in accordance with the views here expressed by the members fixing limits for the thickness of tires of different kinds of wheels

MR LENTZ Before that is put, I would say that I think it is a little irregular. The proper proceeding now, I think, would be to bring the original resolution again before the convention and vote that down, and then Mr Casanave can bring in his resolution

MR WALLIS I hope that will not be voted down, for this reason We all know we are in need of some limit for the built up steel-tired wheels This little V that is placed on the side will give us that information The amendment proposed by Mr Watt requires that wheels fused to tire shall have the V fixed at another point That seems to be satisfactory to the users of those wheels It will give them the limit they want It will give to others using the built up wheel the limit they want and it will put us in a position where we have something to act on during the coming year, rather than the way we have been acting for a long time

MR CLOUD The motion is as first amended before this reconsideration, that a special thickness be made for the limit of tires on wheels which have the tires welded to the centres, and it would make No 1 read as follows That the limit for thickness of tires of steel tired wheels in which the tire is not welded to the centre shall be one inch measured normally to the tread and radially to the curved portions of the flange through the thinnest part within 4½ inches from the back of the flange—the thickness from the latter point to the outer edge of the tread to be not less than half an inch at thinnest part and that the limit of thickness of tires on wheels having centres welded to tires shall be five-eighths of an inch

The motion was lost

The President Now we are ready for your motion, Mr Casanave

Steel tired Wheels

MR CASANAVE I renew my motion that the subject be recommitted to the Committee with instructions to change the recommendations in accordance with the desire of some of the members, and that they report at a later session of this convention

The motion was carried

THE PRESIDENT *(at a subsequent session)* We will now hear from the Committee on Steel-Tired Wheels This report was recommitted to the Committee

MR MARSHALL The Committee on Steel Tired Wheels has considered the question which was referred back to it of making a special limit for certain wheels which have the tires fused to the centres It finds that there would be some difficulty in arranging to make a concession of that kind, that it would bring up the necessity of making similar concessions for some other constructions of wheels, and it, therefore, recommends that the recommendations of the Committee as they are given in the report be submitted to letter ballot for adoption as recommended practice of the Association

MR WAITT I move that the report of the Committee be received and their recommendations submitted to letter ballot.

The motion was carried

THE FLEXURE OF AXLES.

It is not possible to place any load however small, on the journals of a pair of wheels and axle without producing flexure of the axle, and in consequence of this flexure the gauge between the wheels is decreased at rail level and increased at the tops of the wheels It has not hitherto been considered necessary to fix any particular limit to *this flexure*, provided the axle is made strong enough to bear the stress produced without risk of failure.

If the axle be symmetrically loaded, and the part between the wheel seats be straight and not tapered, the curve of deflection will be a *true circle, of which the radius is*

$$R = \frac{E\,I}{M}$$

In which E is the modulus of elasticity which varies from 12,000 to 13,000 tons per square inch for iron, but is sometimes as high as 15,000 for the steel of which axles are made

I is the moment of inertia of the section, which for a circle is $\frac{\pi r^4}{4}$, where r is the radius

M is the bending moment, equal to the weight on each journal multiplied by its horizontal distance from the centre of pressure between the wheel and rail

If the axle be tapered between the wheel seats, this equation still holds good but as the diameter increases, so does the radius of curvature, and as this is proportional to the *fourth power of the diameter, the curve will differ considerably from a circular arc*

At the wheel seats, the axle, being firmly fixed in the boss of the wheel, will remain straight but the curvature will extend for a short distance inside the inner face of the boss, this distance depending on the accuracy with which the axle and boss fit one *another The backs of the wheel flanges will be parallel to and will have the same* splay as the radius of curvature at this point This splay is in no way affected by the flexure of the journals, or of the part of the axle between the journal and wheel boss

For the standard 5ft 6in gauge axles, the distance between centres of journals *is 87 inches and between centres of rails 68·4 inches, the distance from centre of journal* to centre of rail is therefore 9·3 inches when the wheels are centrally placed, but to allow for variations it may be taken as 9·5 inches *

The journal load on the 12-ton axle may be taken as 5·5 tons on each journal, the *centre of the axle is 5½ inches diameter, tapering to 6¼ near the wheel seats.*

The radius of curvature at centre for an iron axle is therefore not less than

$$R_1 = \frac{12{,}000 \times 2\cdot75^4 \times \pi}{9\cdot5 \times 5\cdot5 \times 4} = 10{,}316 \text{ inches}$$

and near wheel seat it is not less than

$$R_2 = \frac{12{,}000 \times 3\cdot125^4 \times \pi}{9\cdot5 \times 5\cdot5 \times 4} = 17{,}202 \text{ inches}$$

The length of axle which bends may be taken as 60 inches, or a little more than the distance between backs of bosses, the diameter of the wheel on tread is 43 inches.

* If the journals or wheels be unsymmetrically loaded or placed on the rails, the flexure will be less at one wheel and greater at the other but the total splay will not be very materially affected.

The flexure of axles

Therefore if the axle were 5¼ inches diameter throughout the splay, or difference between the wheel gauge at top and bottom would be for an iron axle not more than

$$\frac{60 \times 43}{10\ 295\ 5} = 0\ 25 \text{ inch nearly}$$

If the axle were 6¼ diameter throughout, the splay would be about 0 15 inch, allowing for the proportions of the various parts, the actual splay will be slightly more than half the sum of these or about 0 22 inches this is about 0 02 inch for every ton carried by the pair of journals The actual variation from gauge is only half this splay, or 0 11 inch with the full load of 11 tons on the journals

The light axle has a minimum diameter at centre of 5 inches tapering to 5¾ at wheel seats and if the total load be 11 tons the weight on each journal will be about 5 tons therefore,

$$R_1 = \frac{12\ 000 \times 2\ 5^4 \times \pi}{9\ 5 \times 5 \times 4} = 7{,}757 \text{ inches}$$

$$R_2 = \frac{12\ 000 \times 2\ 875^4 \times \pi}{9\ 5 \times 5 \times 4} = 13{,}556 \text{ inches}$$

If the axle were 5 inches diameter throughout the splay would be $\frac{60 \times 43}{7{,}736\ 5} = 0\ 334$ of an inch if it were 5¾ throughout it would be 0 19 inch, the actual splay will be about 0 28 inch, equal to 0 028 inch for each ton carried by the pair of journals If the diameter at centre were 5¼ inches the total splay would be about 0 24 inch

For steel axles, the splay would be from 10 to 20 per cent less than that given by the above figures

It should be noted that unless the wagon is moved after being loaded, the friction of the wheels on the rails may prevent the full splay being produced, in the 12 ton axle the friction of each wheel, with a coefficient of one-sixth may be one ton, and as this acts with a leverage of 21 5 inches, it might counteract the tendency to deflect caused by 2¼ tons acting on each journal with a leverage of 9 5 inches, which might increase or decrease the splay by 0 09 inch, it is therefore desirable to move the wagon before making any measurements

For the standard metre gauge axle as illustrated in Plate IX, Vol III, the diameter at centre is 4¼ inches tapering to 4⅜ at wheel seats The journals are 56 inches and the rails 41¼ inches centre to centre allowing a margin we may take the distance from centre of journal to centre of rail as 7 5 inches The load on each journal, with 6 tons axle load, will be about 2 8 tons, the effective length between wheel bosses 36 inches and the diameter of wheels 28 inches

$$R_1 = \frac{12\ 000 \times 2\ 125^4 \times \pi}{7\ 5 \times 2\ 8 \times 4} = 9{,}151 \text{ inches}$$

$$R_2 = \frac{12\ 000 \times 2\ 188^4 \times \pi}{7\ 5 \times 2\ 8 \times 4} = 10{,}286 \text{ inches}$$

If the axles were 4¼ throughout, the splay would be

$$\frac{28 \times 36}{9\ 137} = 0\ 11 \text{ inch}$$

If they were 4⅜ throughout, it would be nearly 0 099 it will actually be nearly 0 11 or rather less than 0 02 inch for each ton on the pair of journals

May, 1895 F W-D

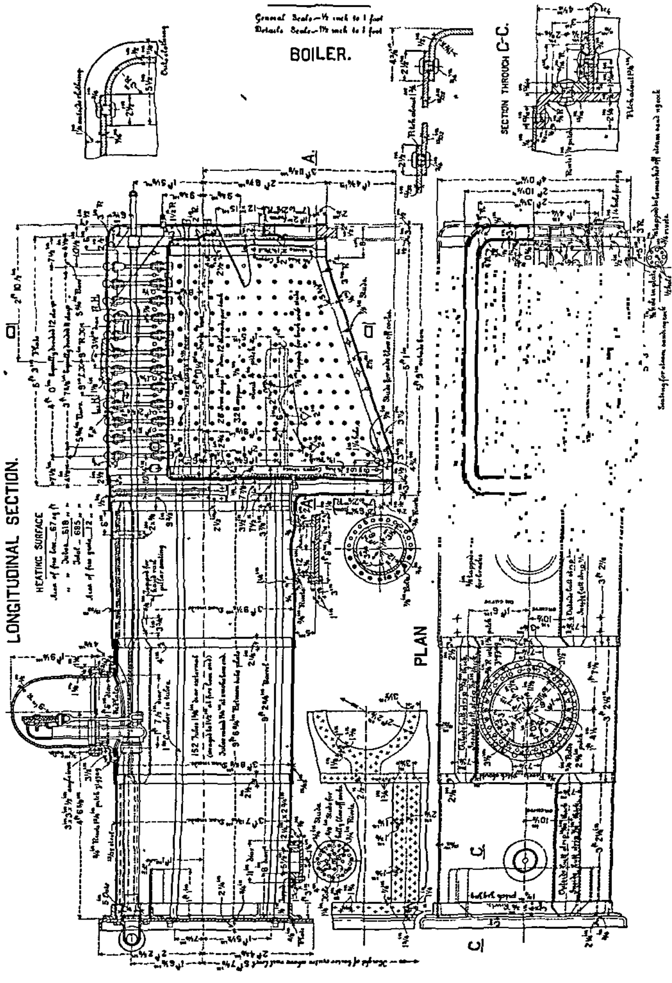
SUBJECT I^A. MIXED & GOODS ENGINE.

CLASS F. MODIFIED.

METRE GAUGE.

NOTE.—For Cross Section, Front and Back Elevations, See PLATE II

APPROVED DESIGN.



SUBJECT I^A. MIXED & GOODS ENGINE.

CLASS F. MODIFIED.

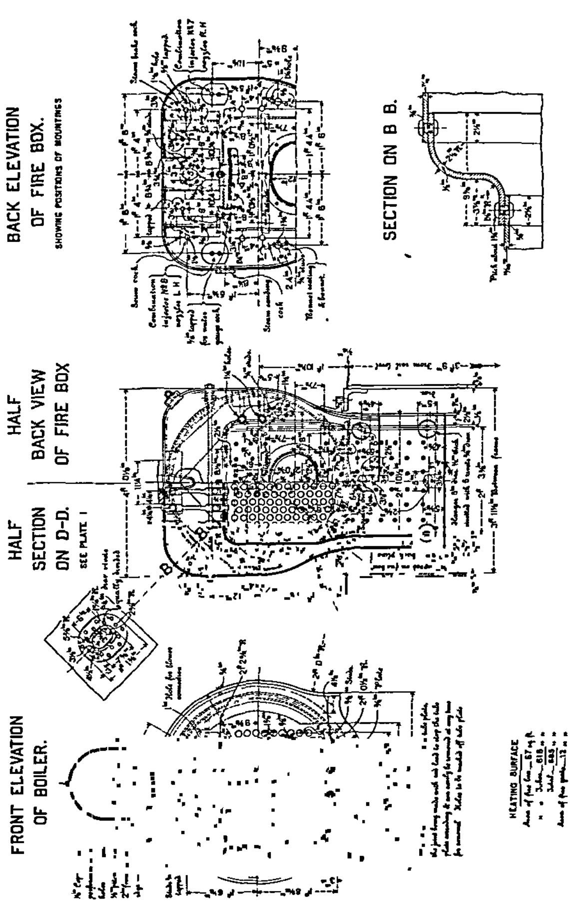
METRE GAUGE.

APPROVED DESIGN.

General—Scale ½ inch to 1 foot
Details—Scale 1½ inch to 1 foot

BOILER.

NOTE —— For Plan and Longitudinal Section, See PLATE I



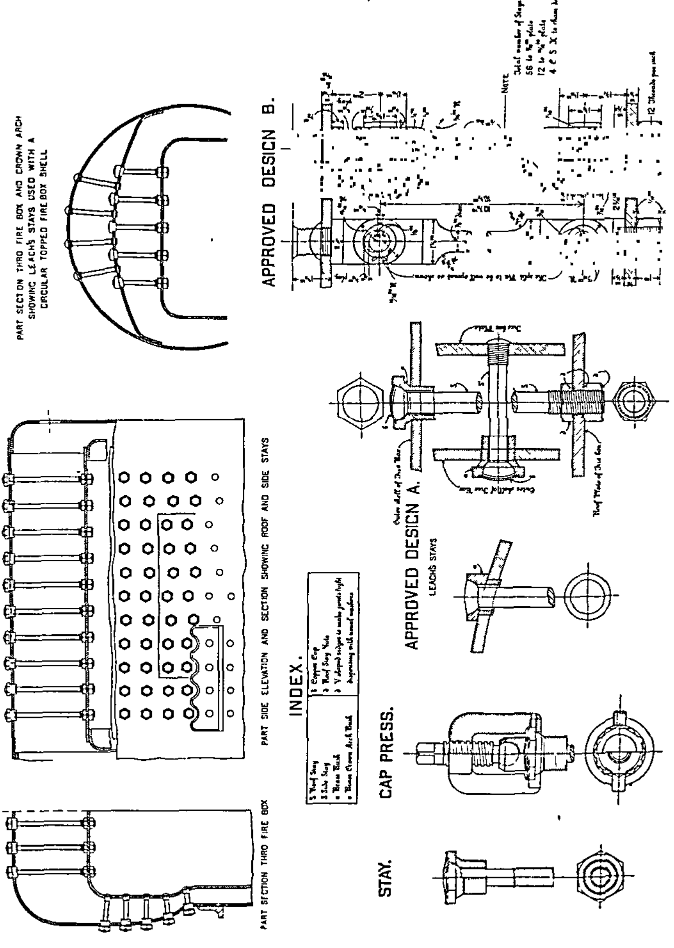
SUBJECT IA. MIXED & GOODS ENGINE.

CLASS F. MODIFIED.

METRE GAUGE.

APPROVED DESIGNS.

General Scale — ½ inch to 1 foot
Details Scale — 3 inches to 1 foot



SUBJECT I^A. MIXED & GOODS ENGINE.

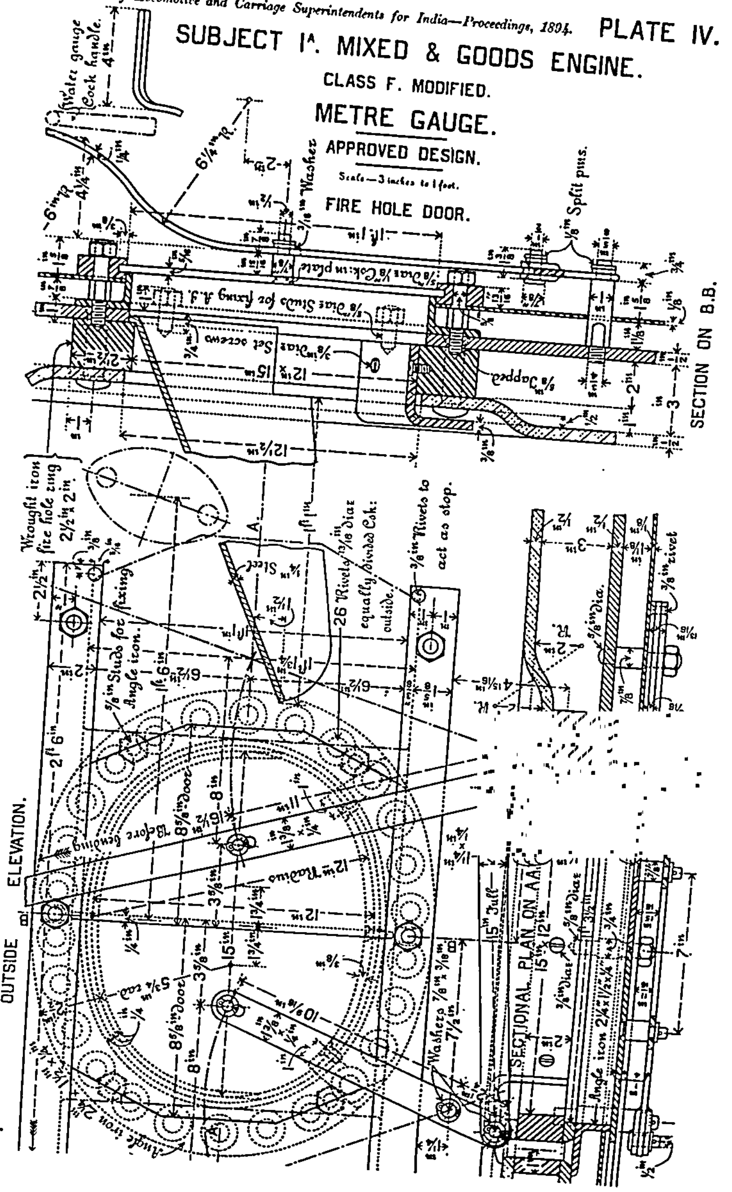
CLASS F. MODIFIED.

METRE GAUGE.

APPROVED DESIGN.

Scale—3 inches to 1 foot.

FIRE HOLE DOOR.



SUBJECT I[A]. MIXED & GOODS ENGINE.

CLASS F. MODIFIED

METRE GAUGE.

APPROVED DESIGN.

Scale—3 inches to 1 foot

FIRE HOLE DOOR.

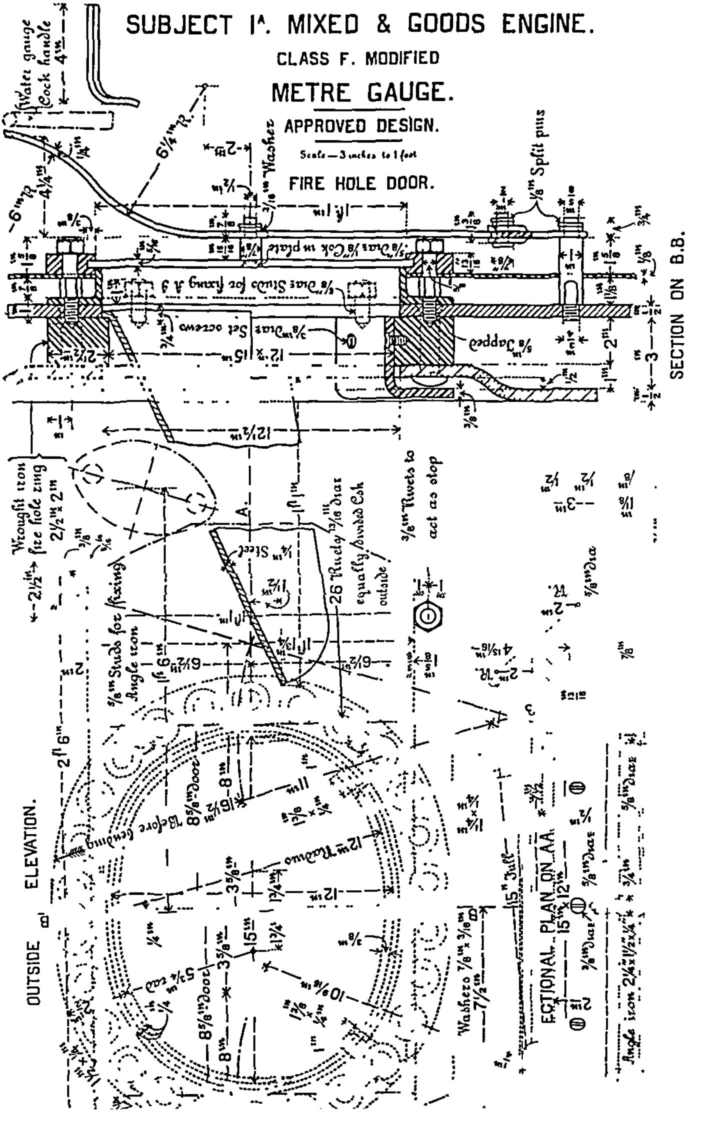


PLATE V.

SUBJECT 1A. MIXED & GOODS ENGINE.

CLASS F. MODIFIED.

METRE GAUGE.

APPROVED DESIGN.

Scale — 3 inches to 1 foot

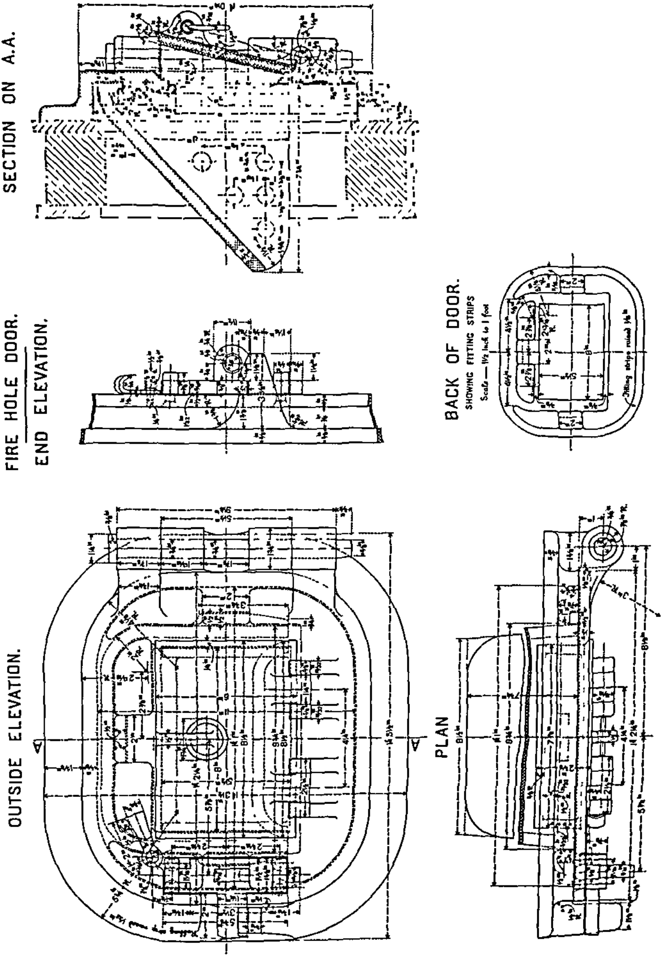


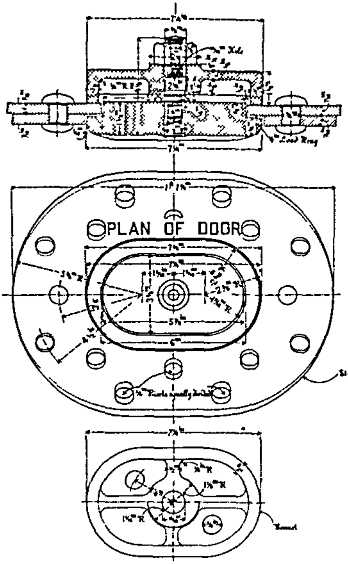
PLATE VI.

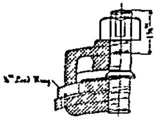
SUBJECT IA. MIXED & GOODS ENGINE.

CLASS F MODIFIED.

METRE GAUGE.

APPROVED DESIGNS



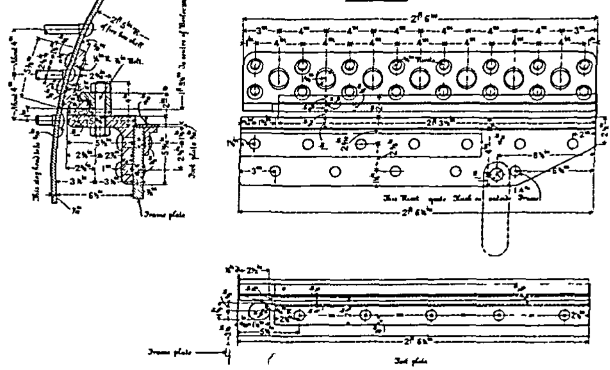


WASH-OUT DOOR

Scale — 3 inches to 1 foot

FIRE BOX SUPPORT

Scale — 1½ inches to 1 foot



SUBJECT I^A. MIXED & GOODS ENGINE.

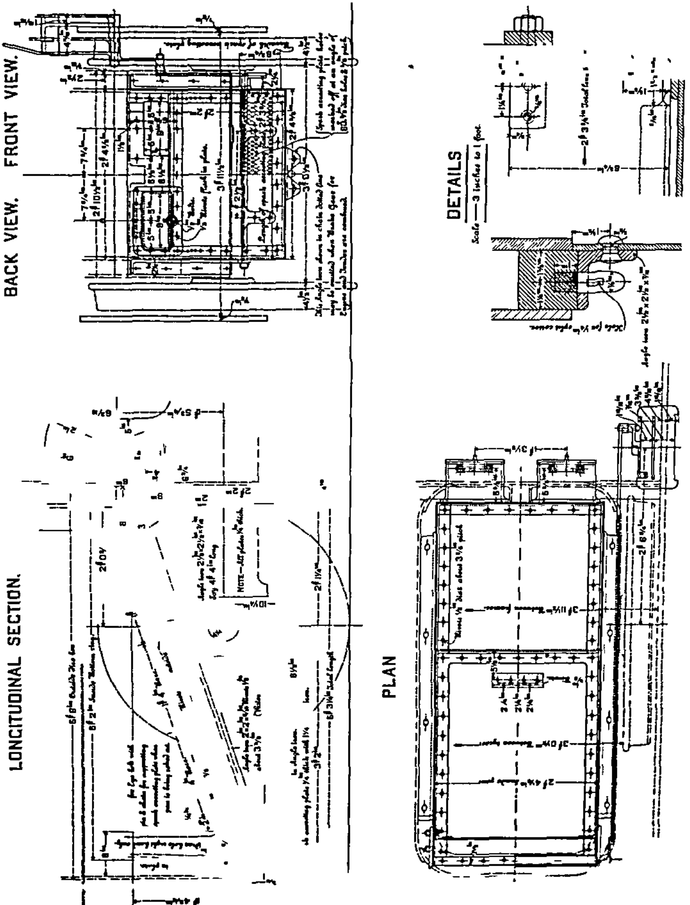
CLASS F. MODIFIED

METRE GAUGE.

APPROVED DESIGN

Scale — 3/4 inch to 1 foot

ASH PAN



SUBJECT 1A. MIXED & GOODS ENGINE.

CLASS F. MODIFIED.

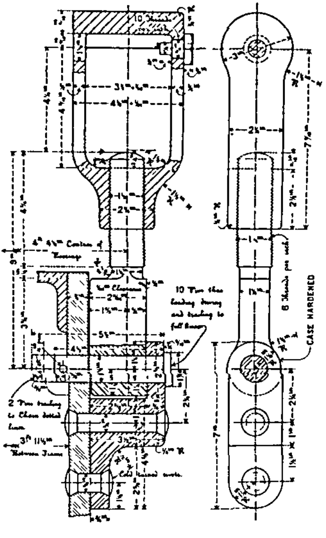
METRE GAUGE.

APPROVED DESIGNS.

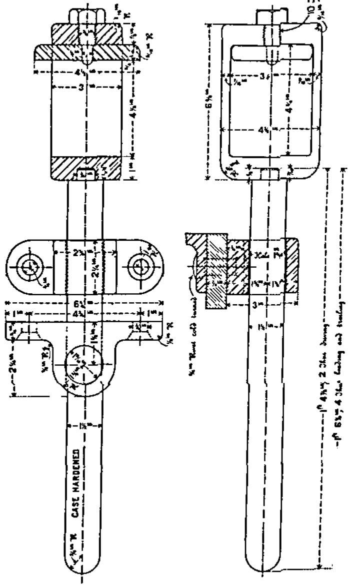
Scale —— 3 inches to 1 foot

SPRING DETAILS.

SPRING HANGER &c.

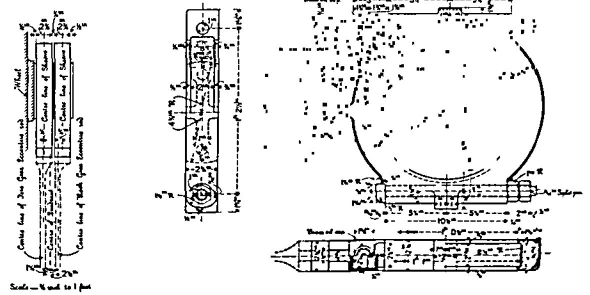


SPRING BUCKLE &c.



ECCENTRIC STRAP &c

Scale —— 1½ inch to 1 foot



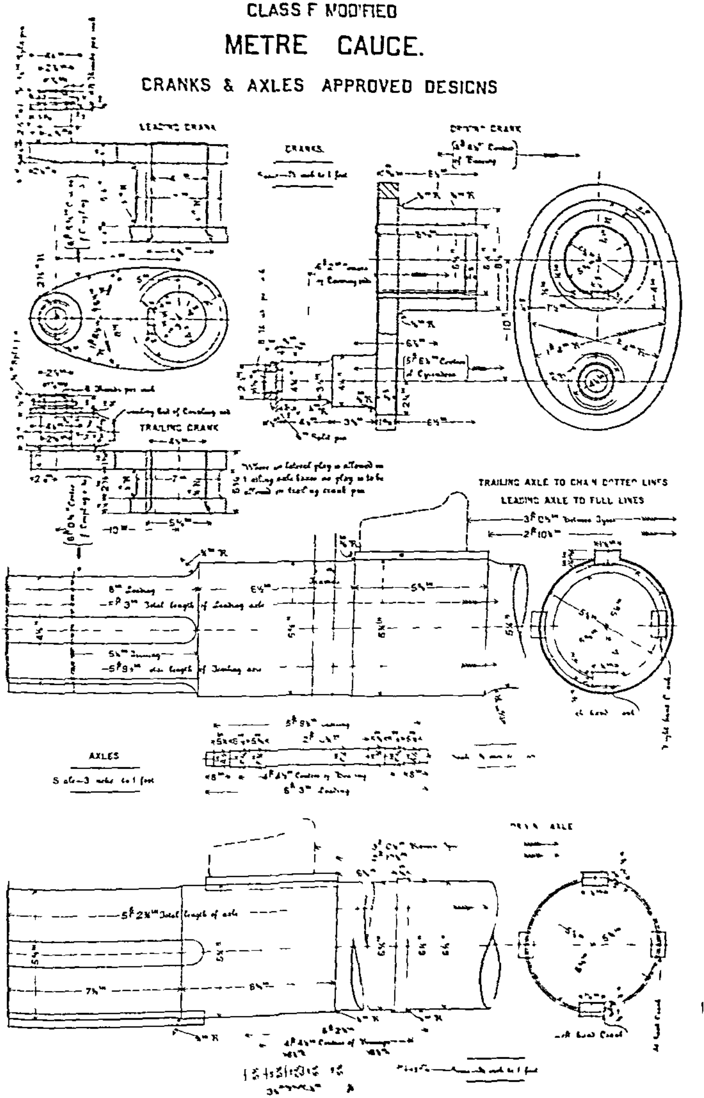
Scale — ¾ inch to 1 foot

SUBJECT I^A. MIXED & GOODS ENGINE.

CLASS F MODIFIED

METRE GAUGE.

CRANKS & AXLES APPROVED DESIGNS



SUBJECT I^A. MIXED & GOODS ENGINE.

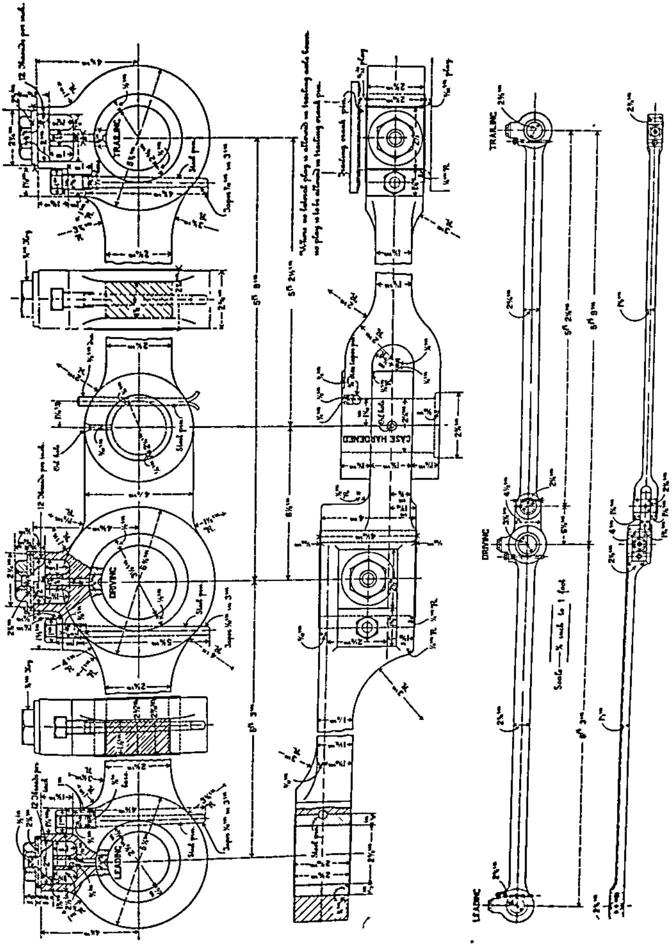
CLASS F. MODIFIED.

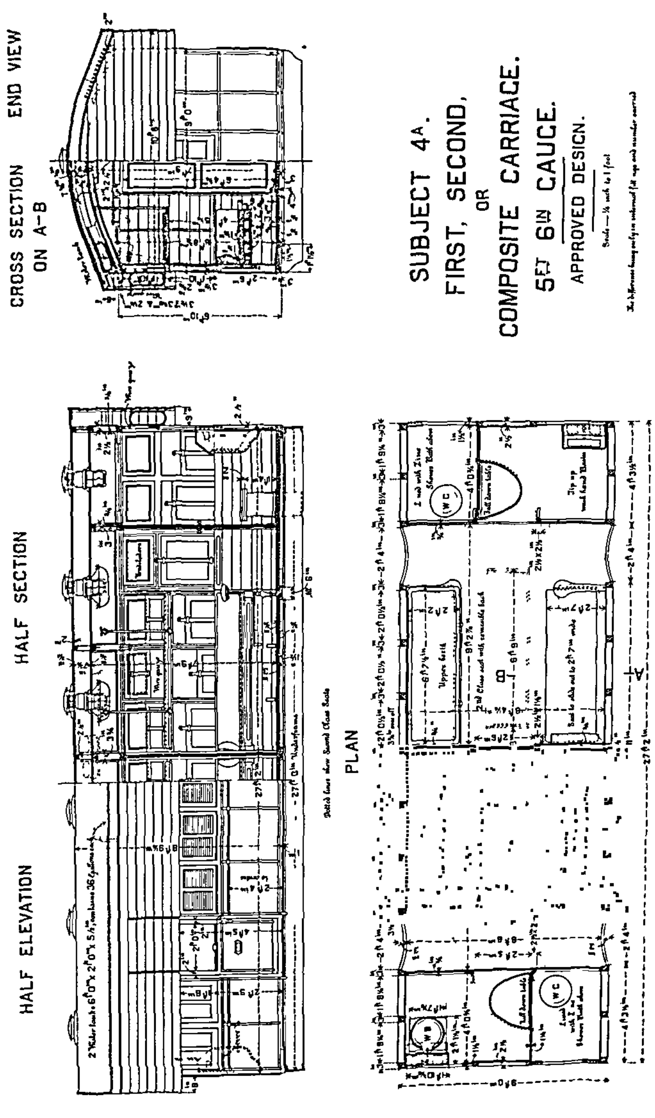
METRE GAUGE.

APPROVED DESIGNS.

Scale — 3 inches to 1 foot.

COUPLING RODS.



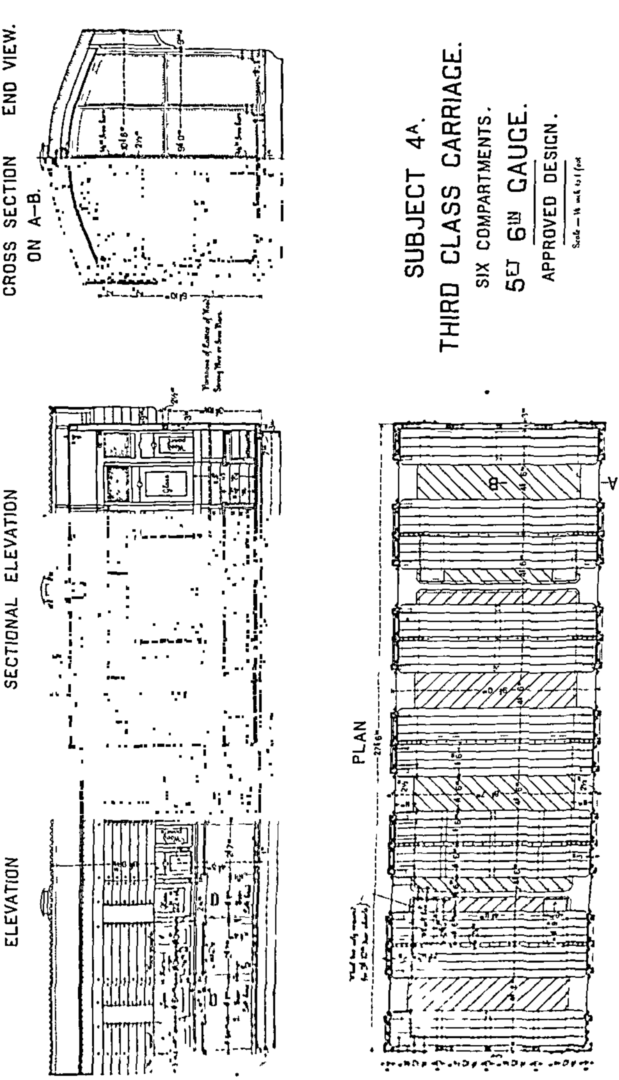


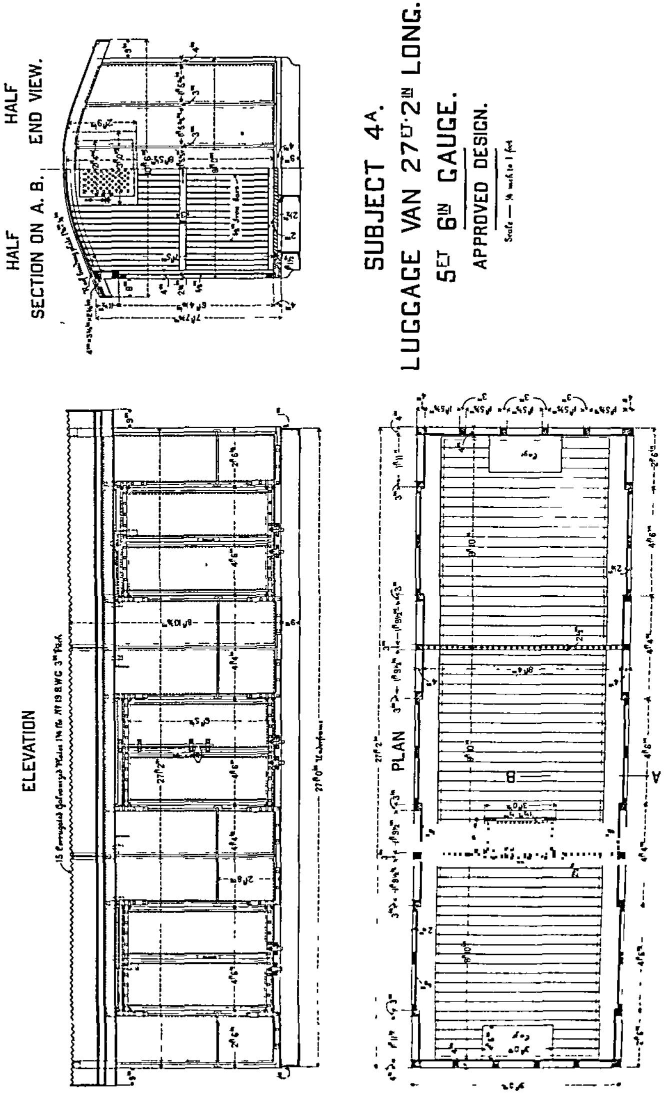
SUBJECT 4A.

FIRST, SECOND, OR COMPOSITE CARRIAGE.

5FT 6IN GAUGE.

APPROVED DESIGN.


ELEVATION
SECTIONAL ELEVATION
CROSS SECTION ON A–B.
END VIEW.
PLAN
SUBJECT 4A.
THIRD CLASS CARRIAGE.
SIX COMPARTMENTS.
5FT 6IN GAUGE.
APPROVED DESIGN.


HALF SECTION ON A. B.
HALF END VIEW.
SUBJECT 4A.
LUGGAGE VAN 27FT 2IN LONG.
5FT 6IN GAUGE.
APPROVED DESIGN.
ELEVATION
PLAN

SUBJECT 4A. BRAKE VAN 27 FT 1 IN LONG. 5 FT 6 IN GAUGE.

APPROVED DESIGN.

Scale — ½ inch to 1 foot

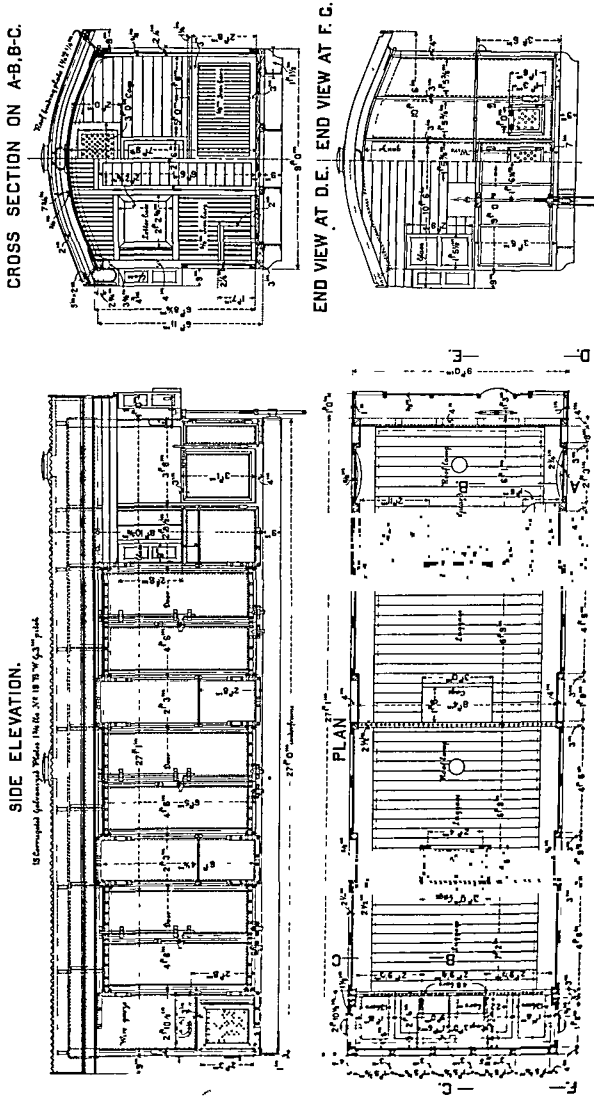
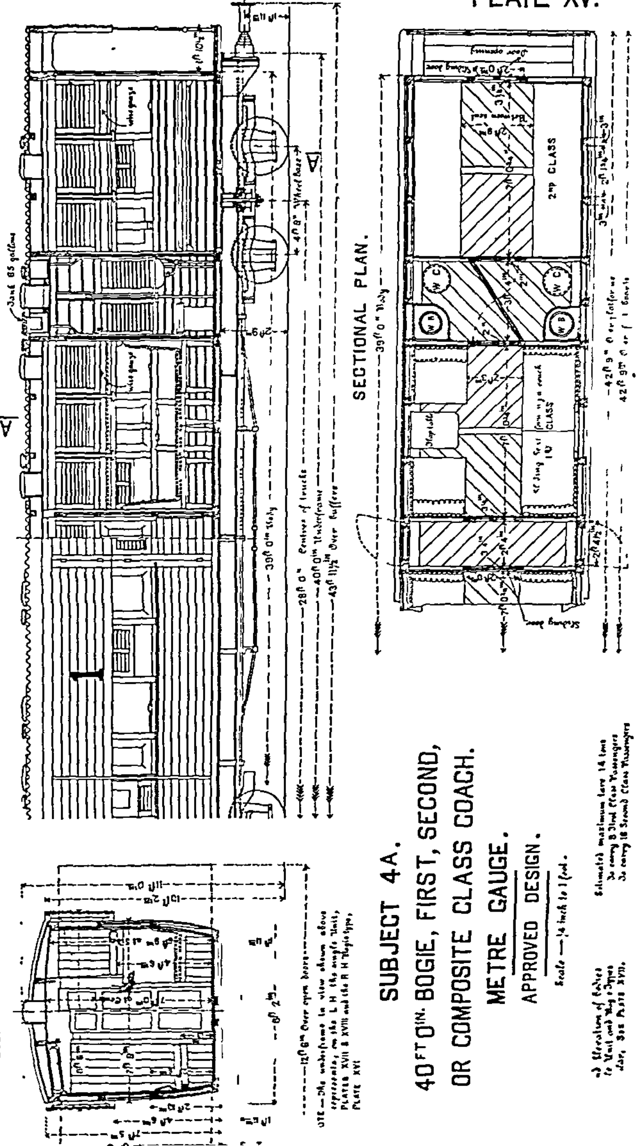


PLATE XV.



SUBJECT 4A.

40FT 0IN. BOGIE, FIRST, SECOND, OR COMPOSITE CLASS COACH.

METRE GAUGE.

APPROVED DESIGN.

Scale — 1/4 inch to 1 foot.

PLATE XVI.

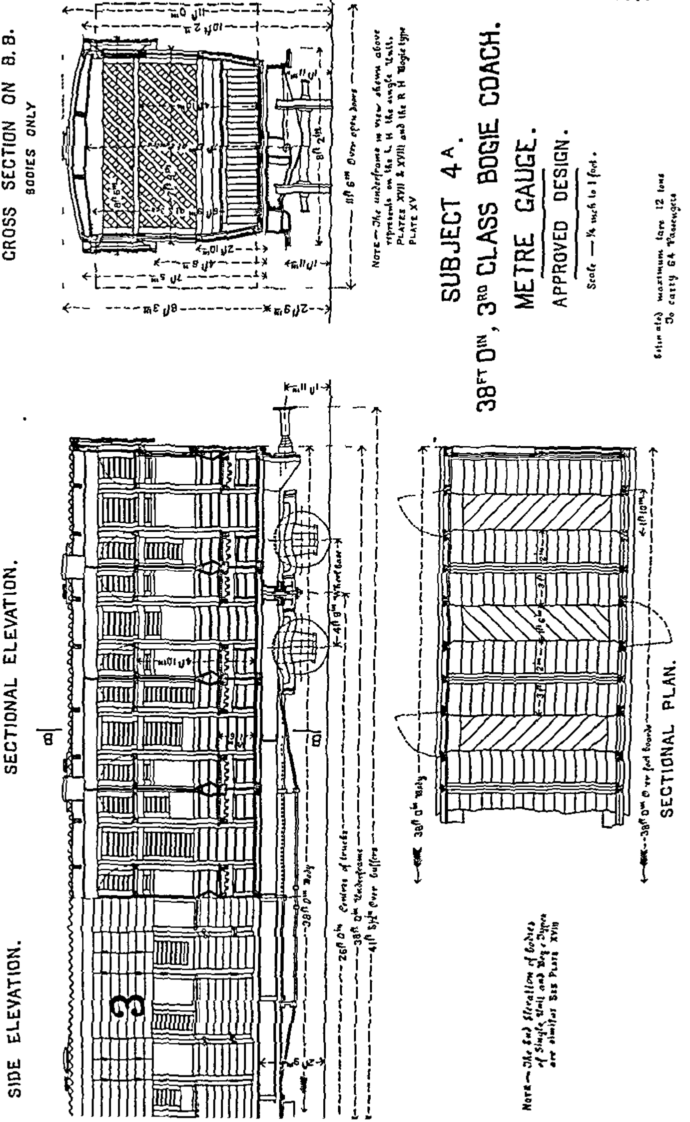
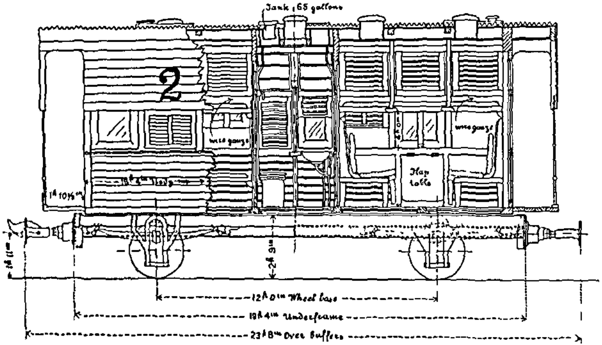
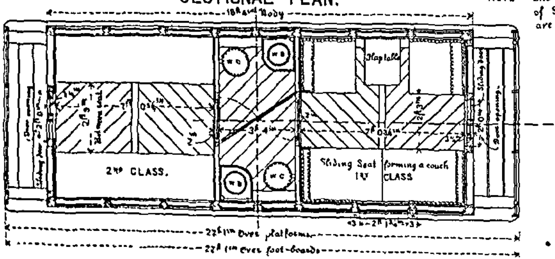

SUBJECT 4 A.
38FT 0IN, 3RD CLASS BOGIE COACH.
METRE GAUGE.
APPROVED DESIGN.
Scale — 1/4 inch to 1 foot.
Estimated maximum tare 12 tons
To carry 64 Passengers
CROSS SECTION ON B.B.
BOGIES ONLY
NOTE—The underframe in view shown above represents on the L.H. the single Unit PLATES XVII & XVIII and the R.H. Bogie type PLATE XV
SIDE ELEVATION.
SECTIONAL ELEVATION.
SECTIONAL PLAN.
NOTE—The End Elevation of bodies of Single Unit and Bogie Types are similar See Plate XVIII
26FT 0IN Centres of trucks
38FT 0IN Underframe
41FT 5½IN Over buffers
38FT 0IN Body
38FT 0IN Over foot boards
4FT 8IN Wheel base
11FT 6IN Over open doors
11FT 0IN
10FT 2IN
8FT 3IN
2FT 9IN
7FT 5IN
4FT 8IN
2FT 10IN
1FT 11IN
8FT 2½IN
4FT 10IN
1FT 10IN

PLATE XVII.

SIDE ELEVATION. SECTIONAL ELEVATION.



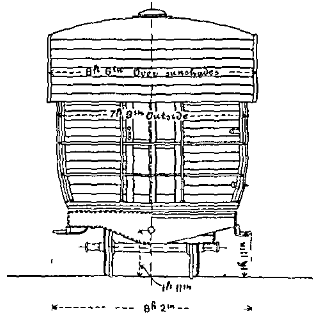
SECTIONAL PLAN.



NOTE — The Cross Section of bodies of Single Unit and Bogie Types are similar, SEE PLATE XV.

END ELEVATION

FOR BOTH SINGLE AND DOUBLE UNIT



NOTE — The underframe in view shewn above represents on the L H the single Unit, PLATE XVIII, and the R H Bogie type, PLATES XV & XVI

SUBJECT 4A.

19FT. 4IN. FIRST, SECOND, OR COMPOSITE CLASS COACH.

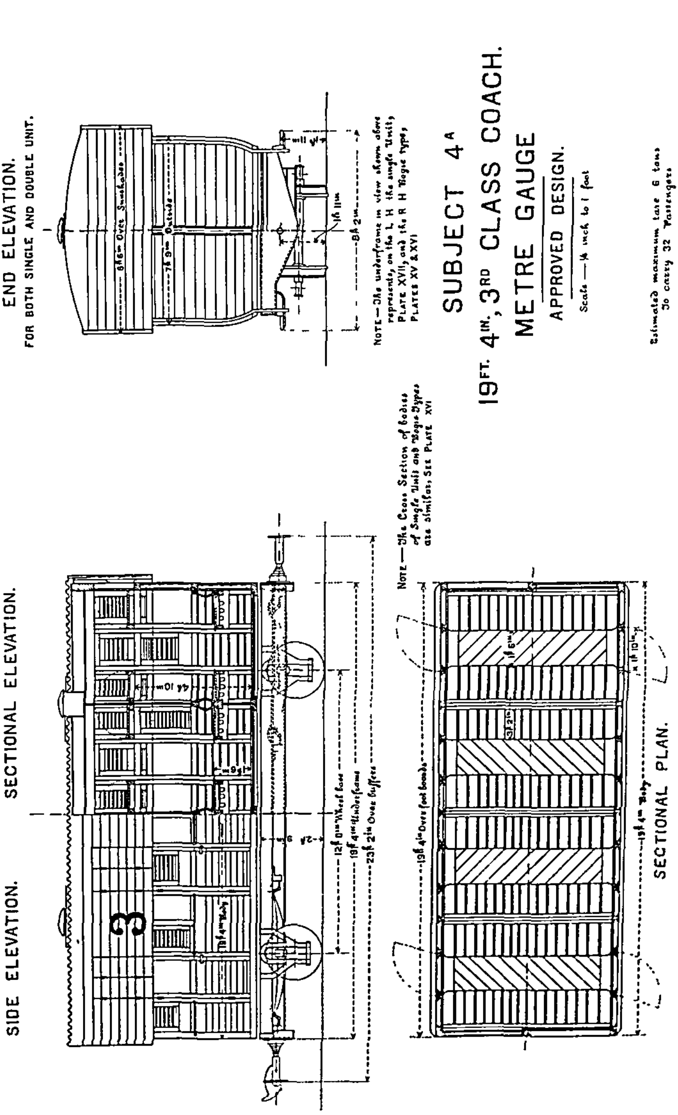
METRE GAUGE.

APPROVED DESIGN.

Scale — ¼ inch to 1 foot

Estimated maximum tare 7 tons
To Carry 4 First Class Passengers
To Carry 8 Second Class Passengers

PLATE XVIII.


END ELEVATION.
FOR BOTH SINGLE AND DOUBLE UNIT.
NOTE—The underframe in view shown above represents, on the L H the single Unit, PLATE XVII, and the R H Bogie types, PLATES XV & XVI
SUBJECT 4A
19FT. 4IN., 3RD CLASS COACH.
METRE GAUGE
APPROVED DESIGN.
Scale — ¼ inch to 1 foot
Estimated maximum tare 6 tons
To carry 32 Passengers
SIDE ELEVATION.
SECTIONAL ELEVATION.
NOTE — The Cross Section of bodies of Single Unit and Bogie Types are similar, SEE PLATE XVI
12ft 0in Wheel base
19ft 4in Underframe
23ft 2in Over Buffers
19ft 4in Over foot boards
19ft 4in Body
SECTIONAL PLAN.

SUBJECT 4c. CARRIAGE FITTINGS.

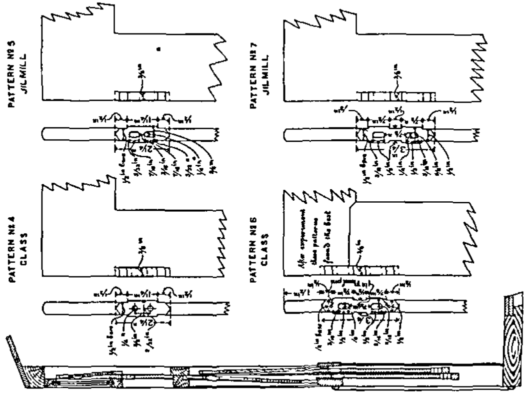
5FT 6IN GAUGE.

APPROVED DESIGNS.

General Scale —— ¾ inch to 1 foot
Details Scale —— 3 inches to 1 foot

PEARCE'S PATENT

INDIA RUBBER CUSHIONS FOR GLASS FRAMES TO PREVENT RATTLING



WINDOW REST CUSHIONS, INDIA RUBBER

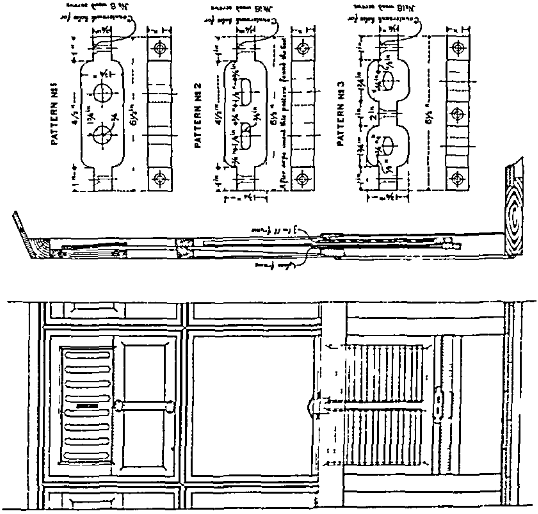


PLATE XX.

SUBJECT 5A.

COVERED GOODS BOGIE WAGONS.

METRE GAUGE.

APPROVED DESIGNS.

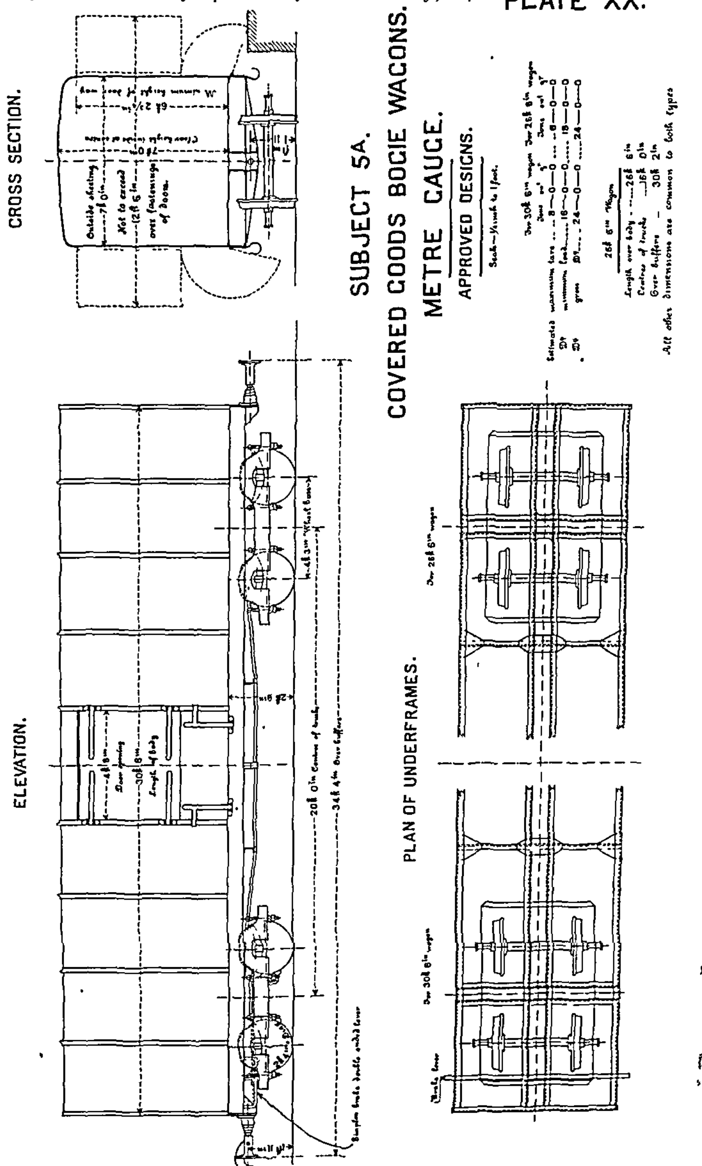
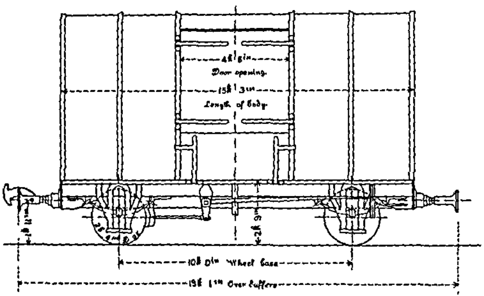
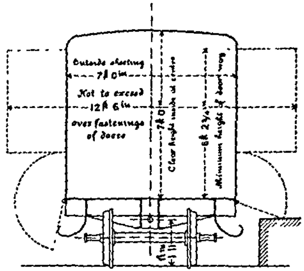


PLATE XXI.

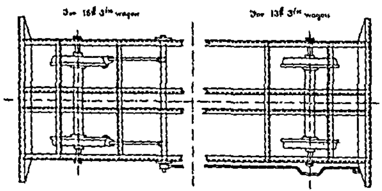
ELEVATION.



CROSS SECTION.



PLAN OF UNDERFRAMES.



SUBJECT 5A.

COVERED GOODS WAGONS.

METRE GAUGE.

APPROVED DESIGNS.

Scale—½ inch to 1 foot.

	For 15 ft 3 in wagon. Tons cwt qr	For 13 ft 3 in wagon. Tons cwt qr
Estimated maximum tare	4—0—0	3—0—0
Do minimum load	8—0—0	9—0—0
Do gross Do	12—0—0	12—0—0

13 ft 3 in Wagon

Length over body	13 ft 3 in
Wheel base	8 ft 0 in
Over buffers	16 ft 11 in

All other dimensions are common to both types.

PLATE XXII.

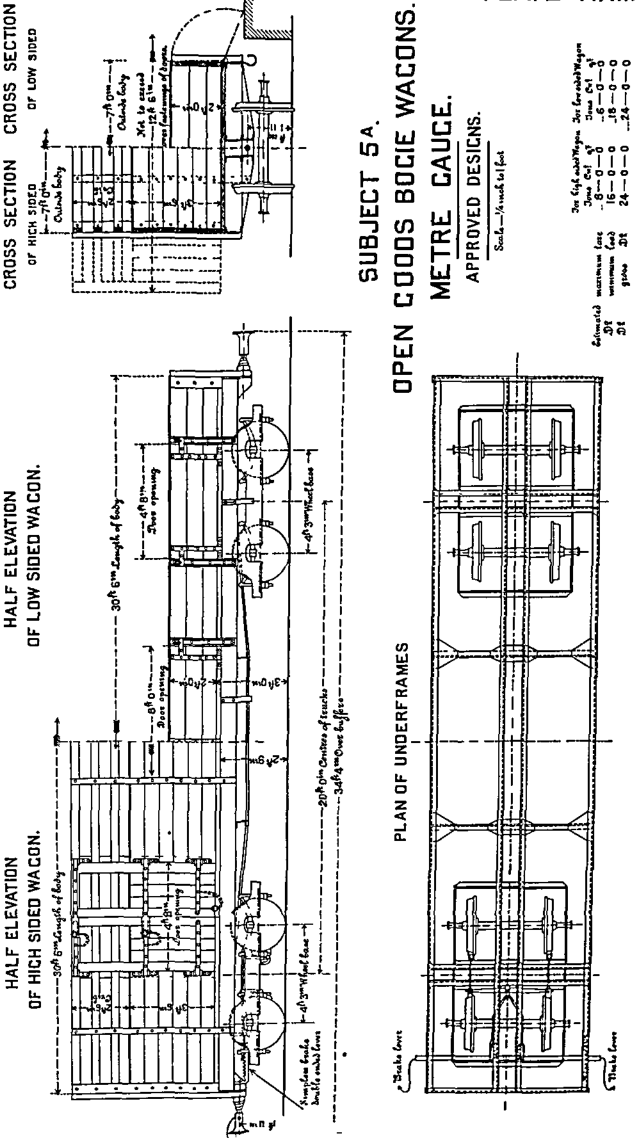

SUBJECT 5A.
OPEN GOODS BOGIE WAGONS.
METRE GAUGE.
APPROVED DESIGNS.
Scale—1/4 inch to foot
For high sided Wagon / For low sided Wagon
Tons Cwt qr / Tons Cwt qr
Estimated maximum tare 8—0—0 / 6—0—0
Do minimum load 16—0—0 / 18—0—0
Do gross 24—0—0 / 24—0—0
CROSS SECTION OF HIGH SIDED
CROSS SECTION OF LOW SIDED
7 ft 0 in Outside body
HALF ELEVATION OF LOW SIDED WAGON.
HALF ELEVATION OF HIGH SIDED WAGON.
30 ft 6 in Length of body
4 ft 8 in Door opening
8 ft 0 in Door opening
4 ft 3 in Wheel base
20 ft 0 in Centres of trucks
34 ft 4 in Over buffers
Simplex brake double ended levers
PLAN OF UNDERFRAMES
Brake lever
Brake lever

PLATE XXIV.

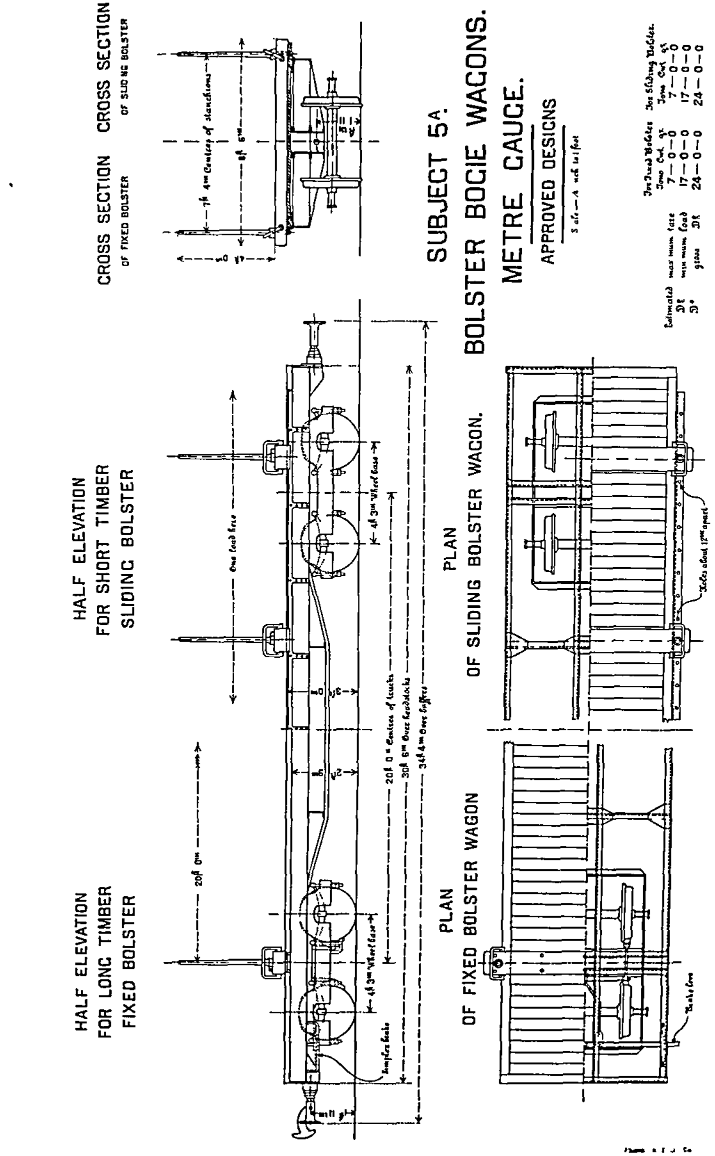
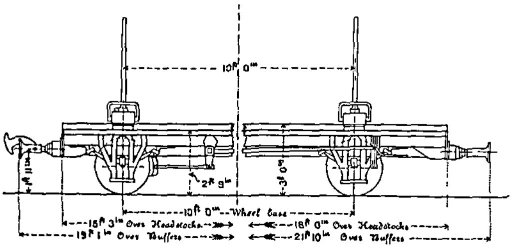
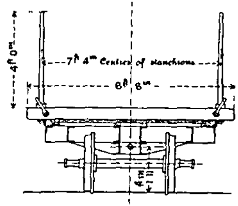

CROSS SECTION
OF FIXED BOLSTER
CROSS SECTION
OF SLIDING BOLSTER
SUBJECT 5A.
BOLSTER BOGIE WAGONS.
METRE GAUGE.
APPROVED DESIGNS
Estimated maximum tare — For Fixed Bolster 7—0—0 — For Sliding Bolster 7—0—0
Do. maximum load — 17—0—0 — 17—0—0
Do. gross — 24—0—0 — 24—0—0
Tons Cwt qr
HALF ELEVATION
FOR SHORT TIMBER
SLIDING BOLSTER
HALF ELEVATION
FOR LONG TIMBER
FIXED BOLSTER
PLAN
OF SLIDING BOLSTER WAGON.
PLAN
OF FIXED BOLSTER WAGON
20ft 0in Centres of trucks
30ft 6in Over headstocks
34ft 4in Over buffers
4ft 3in Wheel base
20ft 0in

PLATE XXV.

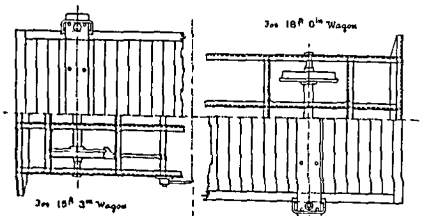
HALF ELEVATION FOR SHORT TIMBER. HALF ELEVATION FOR MEDIUM TIMBER.



CROSS SECTION.



PLAN OF UNDERFRAMES.



SUBJECT 5A.

FIXED BOLSTER WAGONS.

METRE GAUGE.

APPROVED DESIGNS.

Scale—¼ inch to 1 foot

	For 18ft 0in Wagon	For 15ft 3in Wagon
	Tons Cwt qr	Tons Cwt qr
Estimated maximum tare	4 – 0 – 0	3 – 10 – 0
Do minimum load	8 – 0 – 0	8 – 10 – 0
Do gross Do	12 – 0 – 0	12 – 0 – 0

Committee of Locomotive and Carriage Superintendents.

All communications should be addressed to—

The Secretary,
Committee of Loco and Carr Supd s
Public Works Department
Simla

R.S.R.R.
1771
11-5-96

No 4-C. of 189
SIMLA,

12th March

DEAR SIR,

The heading of plate XXVI of the Calcutta proceedings should be—

PEARCE'S END FLAP DOORS

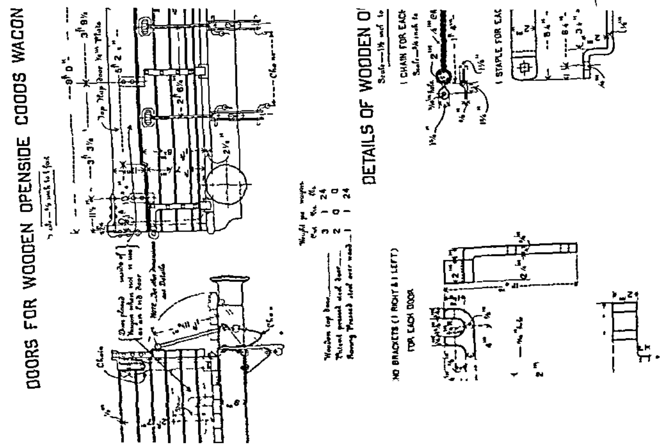
FOR WAGONS—IN PATENT PRESSED STEEL.

Kindly correct your copy accordingly.

I am, Dear Sir,

Yours truly,

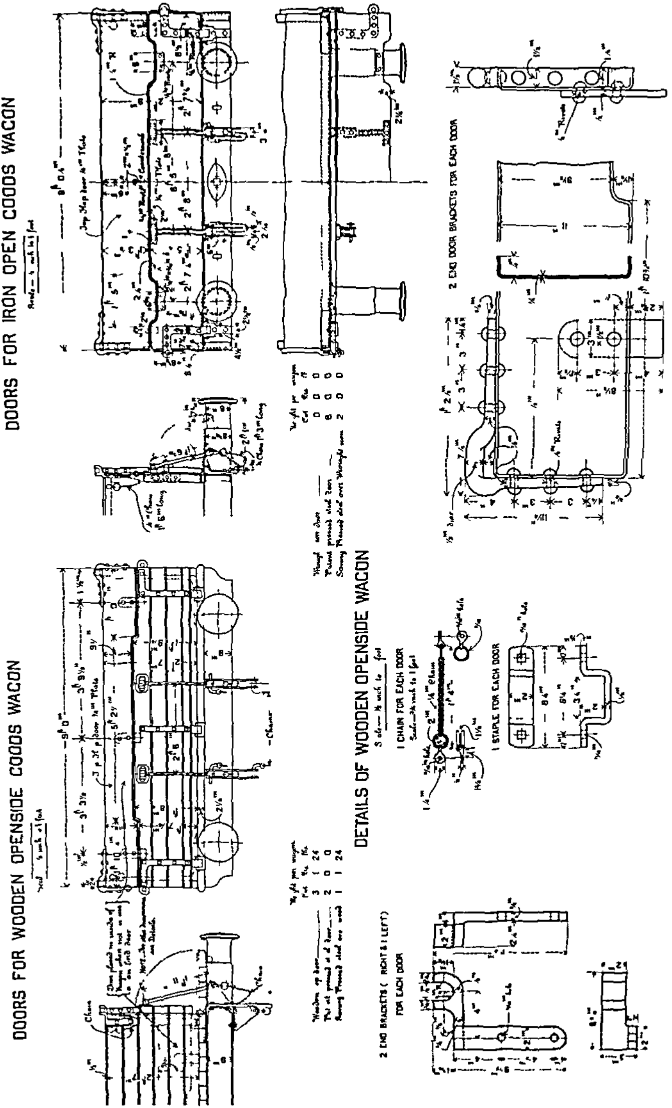
F. WOLLEY-DOD,
Secretary to the Committ



SUB^{CT} 5^{C}.—PRESSED STEEL FLAP DOORS PLATE XXVI

FOR WAGONS — PEARCE'S PATENT — 5^{FT} 6^{IN} GAUGE

APPROVED DESIGNS

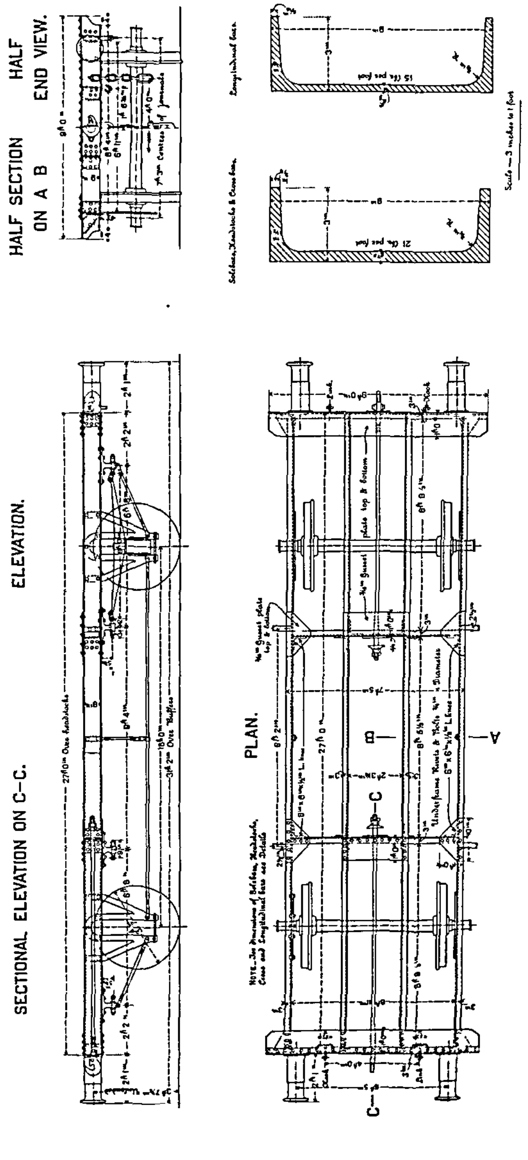


SUBJECT 6A. 27FT 0IN BUILT-UP UNDERFRAME.

5FT 6IN GAUGE.

APPROVED DESIGN

Scale—⅛ inch to 1 foot



SUBJECT 6A.

UNDERFRAME 54 FT 4 IN LONG.— 5 FT 6 IN GAUGE.

FOR BOGIE CARRIAGES.

Scale ¼ inch to 1 foot

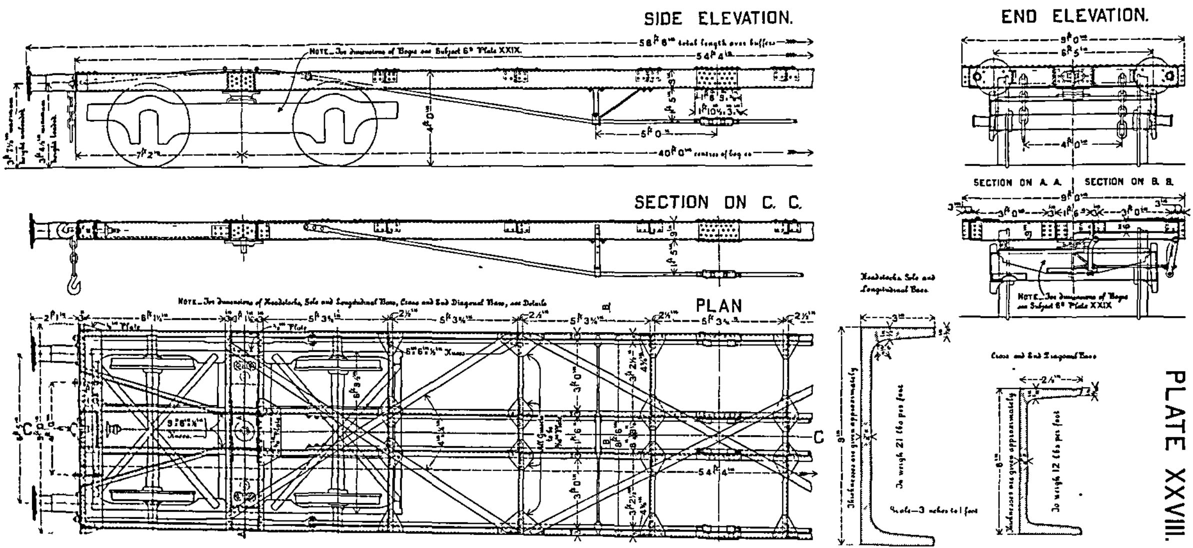
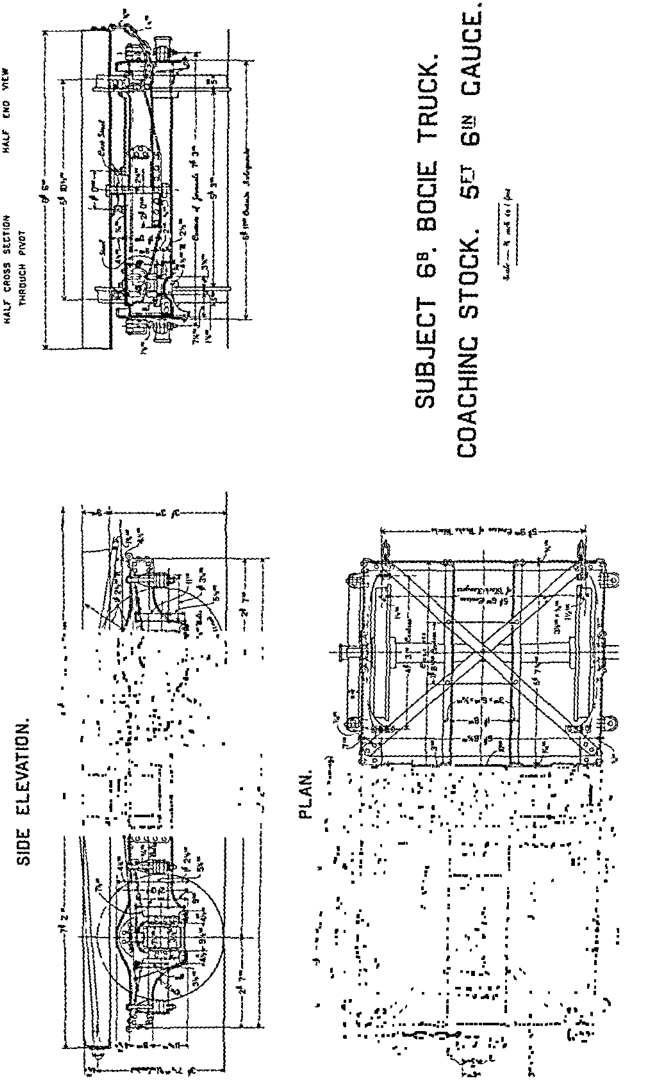


PLATE XXVIII.


HALF CROSS SECTION THROUGH PIVOT
HALF END VIEW
SUBJECT 6B. BOGIE TRUCK.
COACHING STOCK. 5FT 6IN GAUGE.
SIDE ELEVATION.
PLAN.

SUBJECT 6B. BOGIE TRUCKS.

COACHING STOCK. METRE GAUGE.

APPROVED DESIGNS

An an alternative arrangement to that shown in Plates XIX to XXI, Vol V

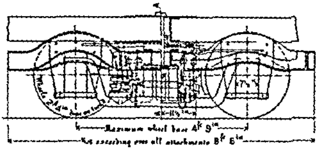
Scale—¾ inch to 1 foot

AXLEGUARDS INSIDE SOLE BARS

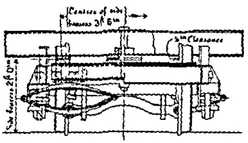
SQUARE FRAMED TRUCK

WITH EQUALIZING BARS & SWINGING BOLSTER

LONGITUDINAL ELEVATION LONGITUDINAL SECTION



CROSS SECTION ON A–A END ELEVATION



PLAN

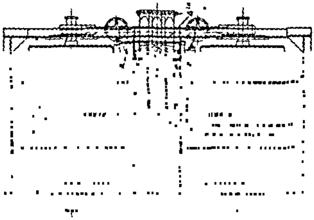
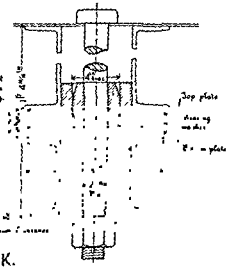


FIG C

PIVOT.

Scale—1½ inch to 1 foot

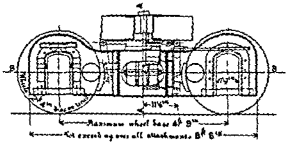
NOTE—These designs of Pivot Plates are to be adopted in place of that shown in Fig. C, of Plate XIX of Vol V



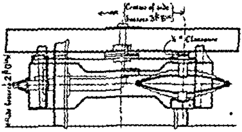
FOX'S PRESSED STEEL TRUCK.

WITH ROCKING BOLSTER

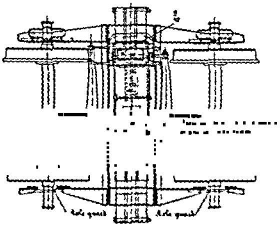
LONGITUDINAL ELEVATION LONGITUDINAL SECTION



END ELEVATION CROSS SECTION ON A–A



PLAN

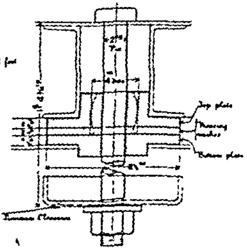


SECTIONAL PLAN ON B B

FIG C

PIVOT

Scale—1½ inch to 1 foot



SUBJECT 6B. BOGIE TRUCKS.

GOODS STOCK. METRE GAUGE.

APPROVED DESIGNS.

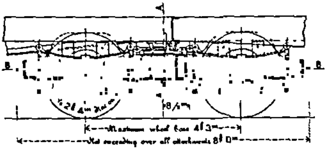
As an alternative arrangement to that shown in Plates XIX to XXI, Volume V

Scale—¾ inch to 1 foot

AXLEGUARDS INSIDE SOLE BARS.

SQUARE FRAMED TRUCK

LONGITUDINAL ELEVATION LONGITUDINAL SECTION



CROSS SECTION ON A–A END ELEVATION

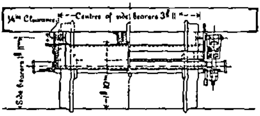
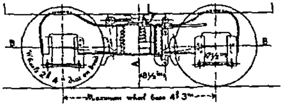


FIG B.

PLAN.

In Plates XXX and XXXI the width of axle guards is shown 7½ inches, the present practice on the South Indian Railway, pending final settlement of this dimension by the Committee.



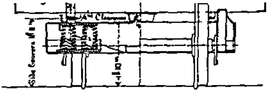
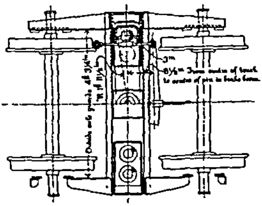


FIG A.

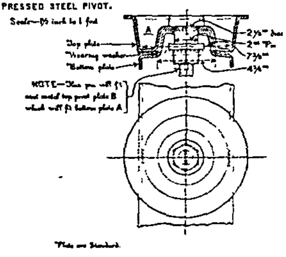
PLAN.



SECTIONAL PLAN ON B–B.

PRESSED STEEL PIVOT.

Scale—1½ inch to 1 foot



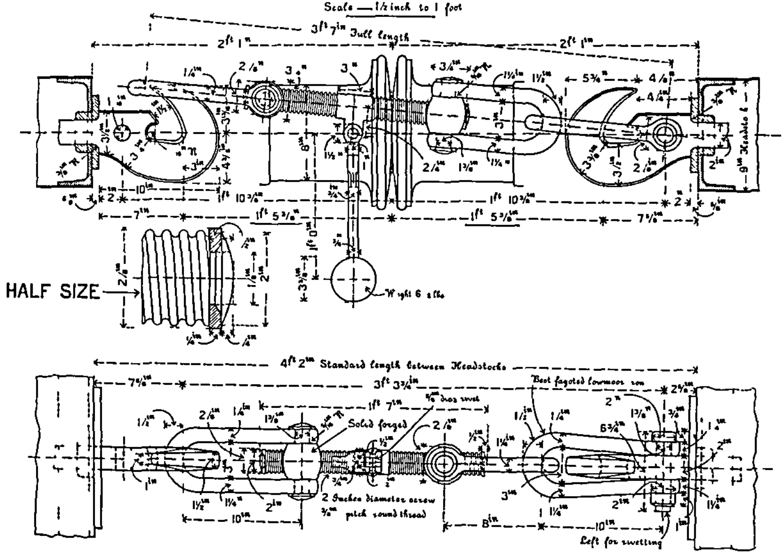
NOTE— Plates are Standard.

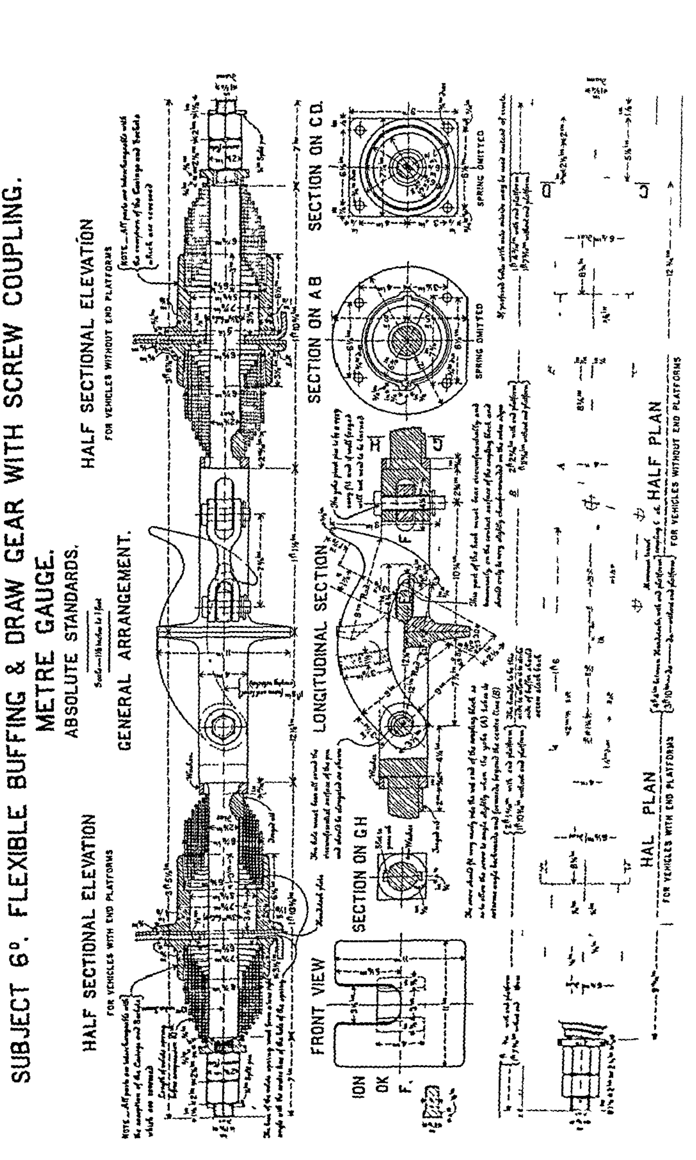
SUBJECT 6D. DISTANCE FROM BIGHT OF HOOK OF DRAWBAR TO FACE OF BUFFER. 5FT 6IN GAUGE.

ABSOLUTE STANDARD.

SCREW COUPLING FOR CARRIAGES & WAGONS.

Scale — 1/2 inch to 1 foot



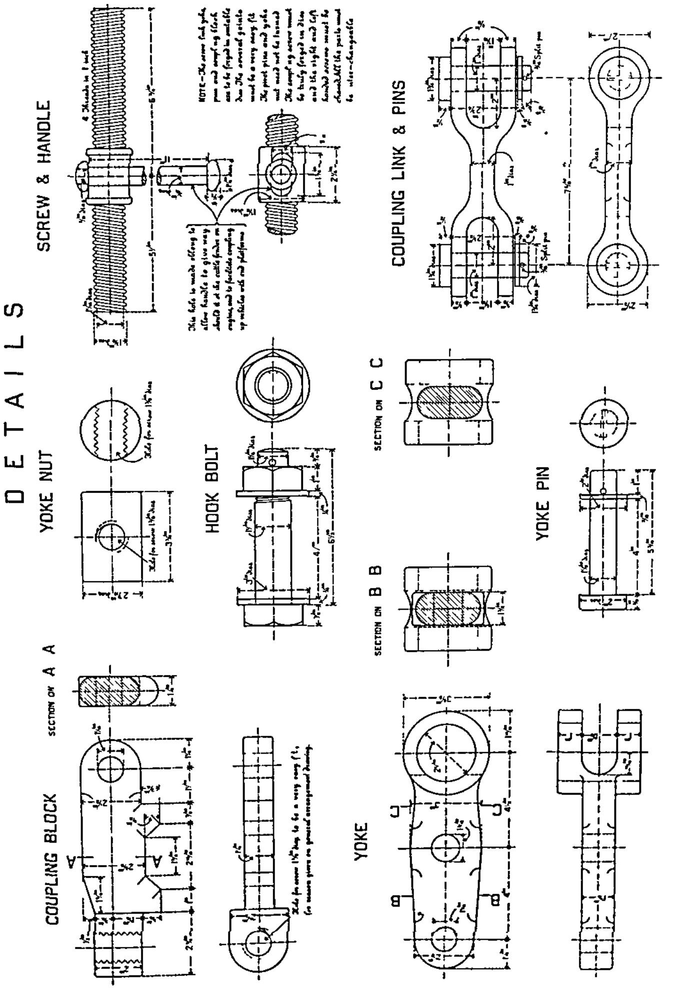

SUBJECT 6°. FLEXIBLE BUFFING & DRAW GEAR WITH SCREW COUPLING.
METRE GAUGE.
ABSOLUTE STANDARDS.
GENERAL ARRANGEMENT.
HALF SECTIONAL ELEVATION
FOR VEHICLES WITH END PLATFORMS
HALF SECTIONAL ELEVATION
FOR VEHICLES WITHOUT END PLATFORMS
SECTION ON CD.
SPRING OMITTED
SECTION ON AB
SPRING OMITTED
LONGITUDINAL SECTION
SECTION ON GH
FRONT VIEW
HALF PLAN
FOR VEHICLES WITH END PLATFORMS
HALF PLAN
FOR VEHICLES WITHOUT END PLATFORMS

SUBJECT 6º. PLATE XXXIV.

FLEXIBLE BUFFING & DRAW GEAR
WITH SCREW COUPLING
METRE GAUGE.

ABSOLUTE STANDARDS

Scale—3 inches to 1 foot

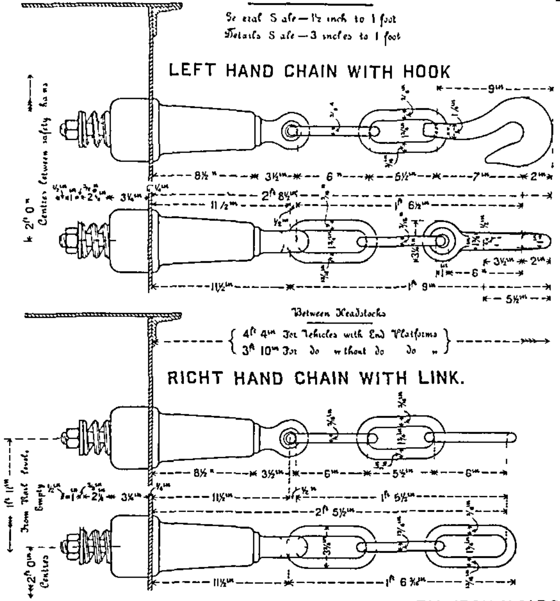


SUBJECT 6D. SAFETY SIDE CHAINS.

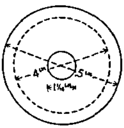
METRE GAUGE

ABSOLUTE STANDARDS WHEN WINTERS INTERCOMMUNICATION IS NOT USED.

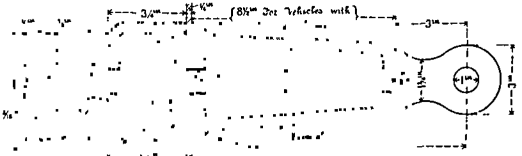
General Scale — 1½ inch to 1 foot
Details Scale — 3 inches to 1 foot



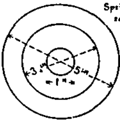
PLAN OF CAST IRON WASHER



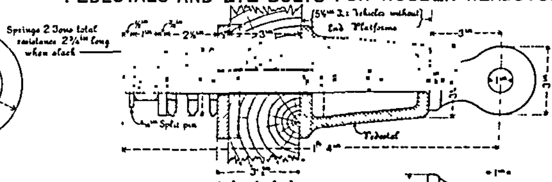
PEDESTALS AND EYE BOLTS FOR IRON HEADSTOCKS.



PLAN OF CAST IRON PEDESTAL

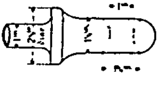


PEDESTALS AND EYE BOLTS FOR WOODEN HEADSTOCKS.



NOTE—The terms right hand and left hand are as indicated by the hands of a person standing between the rails and facing the end of the Vehicle

The long and Short Pedestals for Vehicles with End and without End Platforms are Similar for both iron and wooden headstocks.

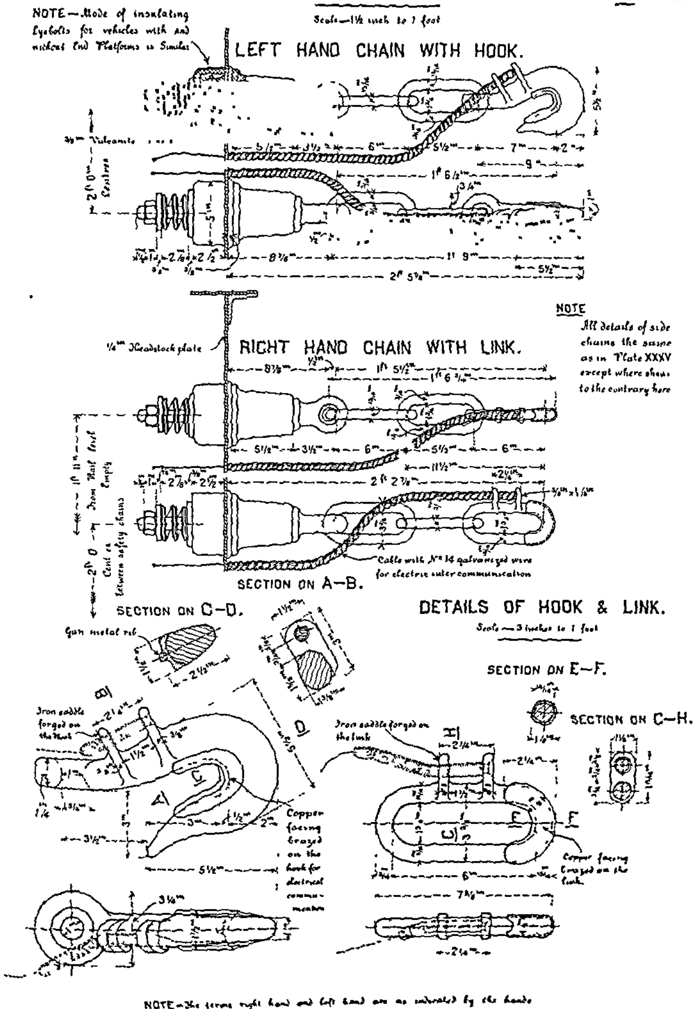


SUBJECT 6º. SAFETY SIDE CHAINS.

FITTED WITH WINTER'S ELECTRIC INTERCOMMUNICATION.

METRE GAUGE.

ABSOLUTE STANDARDS, WHEN WINTER'S INTERCOMMUNICATION IS USED.



NOTE

All details of side chains the same as in Plate XXXV except where shewn to the contrary here

NOTE—The terms right hand and left hand are as indicated by the hands of a person standing between the rails and facing the of the vehicle

SUBJECT 7B. ROLLED TYRE.

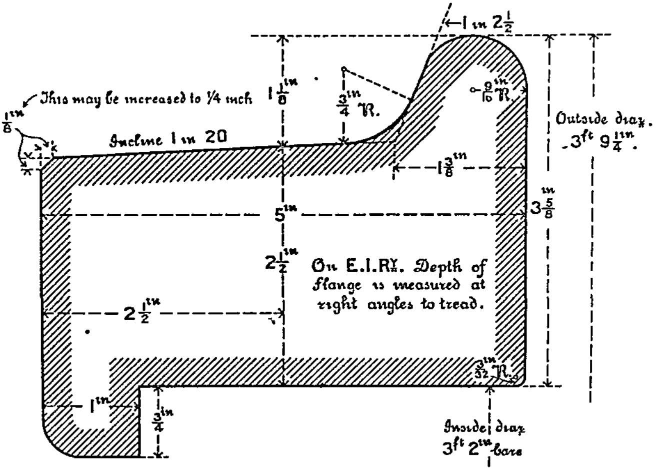
PROVISIONAL STANDARD.

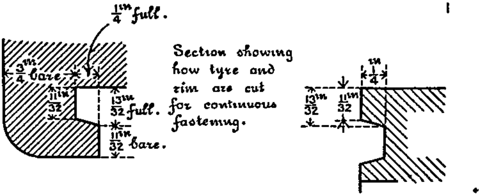
Standard Section for use with all Wheels except those fitted with Mansell Fastening.

5 FT 6 IN GAUGE.

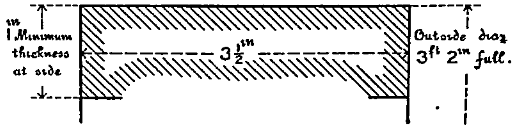
Full size.

Dimensions show size when finished.





STANDARD OUTLINE OF RIM.



SUBJECT 7B. SYSTEMS OF FASTENINGS, CAPABLE OF BEING ADAPTED TO STANDARD SECTION OF TYRE.

5 FT. 6 IN GAUGE.

Half Size

FIG. I.

I. S.R. STANDARD

WITH RING FASTENING.

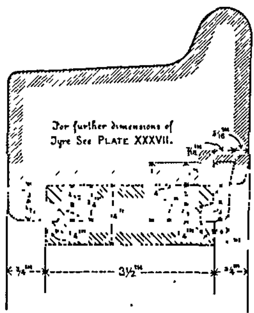
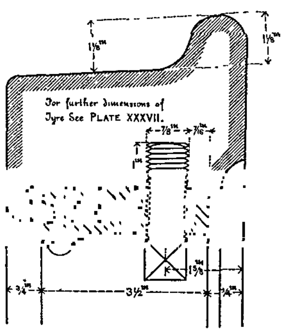


FIG. 2.

E. I.R. STANDARD

WITH STUD FASTENING.



NOTE—For dimensions of Provisional Standard ROLLED TYRE and RIM See Plate XXXVII.

SUBJECT 7B. SYSTEMS OF FASTENINGS, CAPABLE OF BEING ADAPTED TO STANDARD SECTION OF TYRE.

5 FT 6 IN GAUGE.

Half Size

FIG. I.
I. S.R. STANDARD
WITH RING FASTENING.

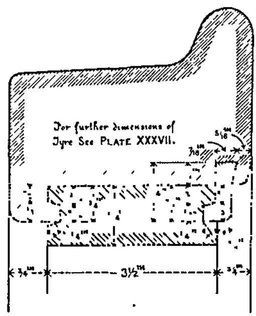
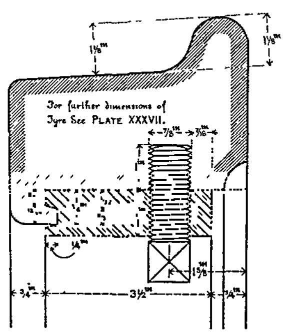


FIG. 2.
E. I.R. STANDARD
WITH STUD FASTENING.



NOTE—For dimensions of Provisional Standard ROLLED TYRE and RIM See Plate XXXVII.

SUBJECT 7B. SECTIONS OF TYRES AND FASTENINGS.

5 FT 6 IN GAUGE.

Half Size

FIG. 1.

M.R.C. STANDARD.

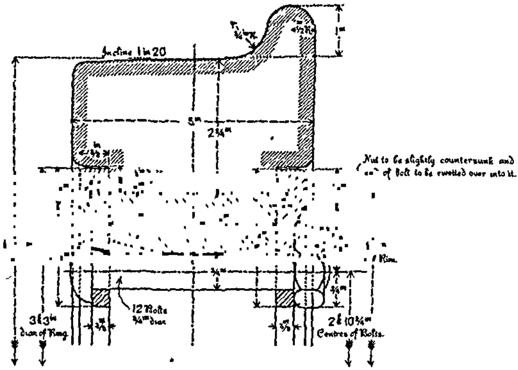
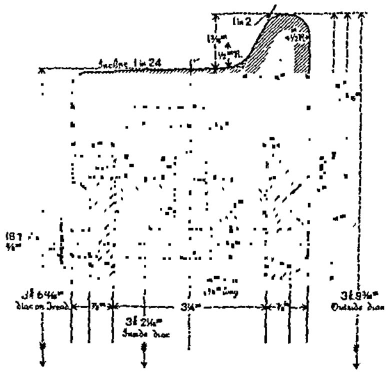


FIG. 2.

I.M.R. STANDARD.



SUBJECT 7B. SECTIONS OF TYRES AND FASTENINGS.

5 FT 6 IN GAUGE.

Half Size

FIG. I
M.R.C. STANDARD.

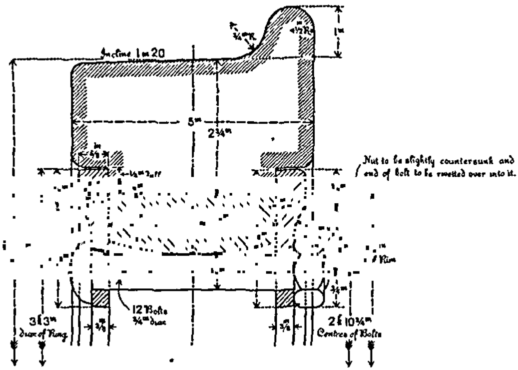
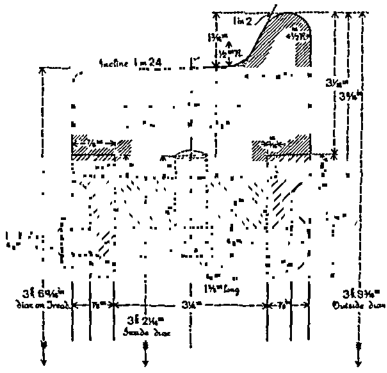


FIG. 2.
I.M.R. STANDARD.



SUBJECT 7^B. ROLLED TYRE.

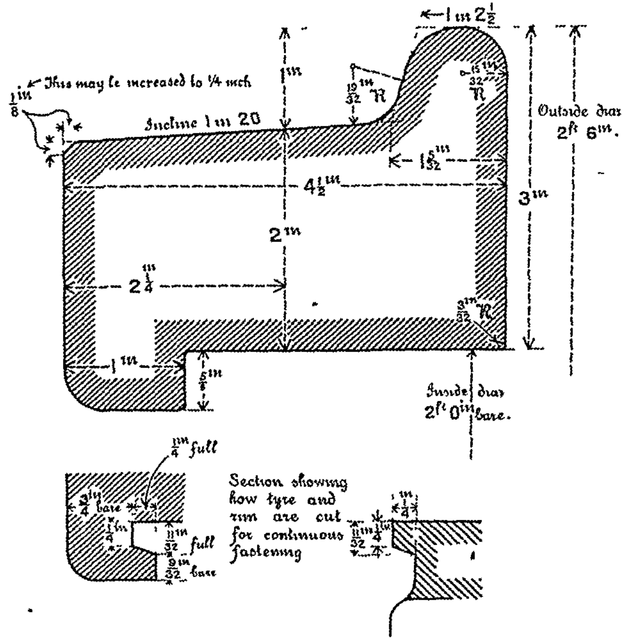
PROVISIONAL STANDARD.

Standard Section for use with all Wheels except those fitted with Mansell Fastening.

METRE GAUGE.

Full size.

Dimensions show size when finished.



STANDARD OUTLINE OF RIM.

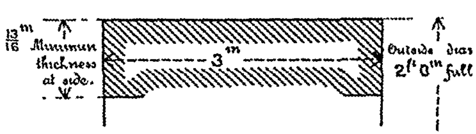


PLATE XLI.

SUBJECT 7B. SYSTEMS OF FASTENINGS, CAPABLE OF BEING ADAPTED TO STANDARD SECTION OF TYRE.

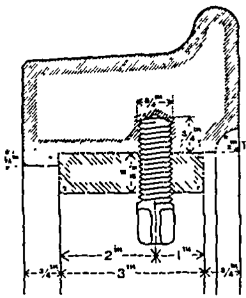
METRE GAUGE.

Half size

A.

STUD FASTENING.

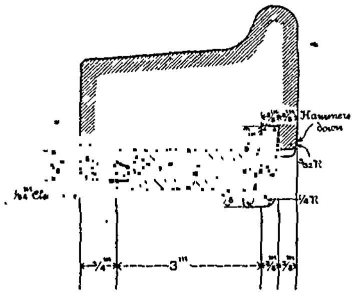
(*Latest practice*)



B.

GLUT FASTENING.

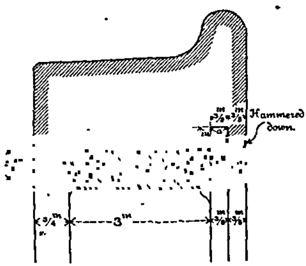
(Vol V PLATE XXI)



NOTE—*Edges marked 'a' to be rounded*

C.

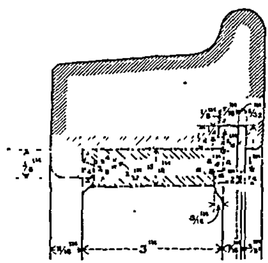
RING FASTENING.



D.

DOUBLE RING FASTENING.

(*Stroudley & Carltons*).



NOTE— *For dimensions of Provisional Standard* ROLLED TYRE *and* RIM *See Plate* XL.

SUBJECT 7C.

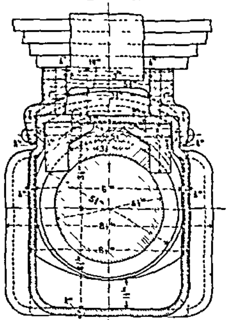
PRESSED STEEL AXLE BOX

AND CLIP FOR BEARING SPRING

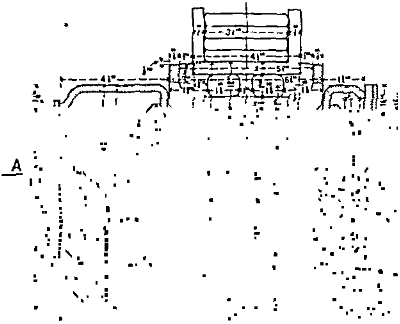
5FT 6IN GAUGE.

Scale—3 inches to 1 foot

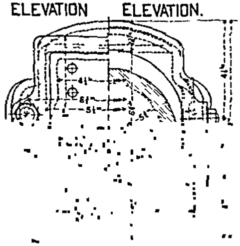
CROSS SECTION THRO CENTRE



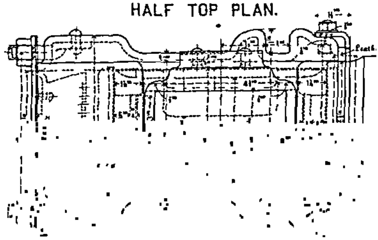
LONGITUDINAL SECTION



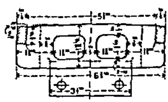
HALF FRONT ELEVATION HALF BACK ELEVATION.

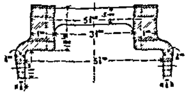


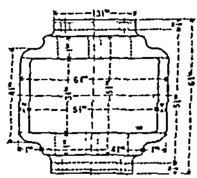
HALF TOP PLAN.



HALF SECTIONAL PLAN ON A. A.







Weight of Pressed Steel Box V Cast iron Box

Description	Pressed Steel	Cast iron
Box only	48 lbs	108 lbs
Clip	6 lbs	—
Brass	15 lbs	15 lbs
Total	63 lbs	123 lbs

Nearly 2 Cwt per Vehicle in favour of Pressed Steel.

SUBJECT 7c.

CAST IRON AXLE BOX.

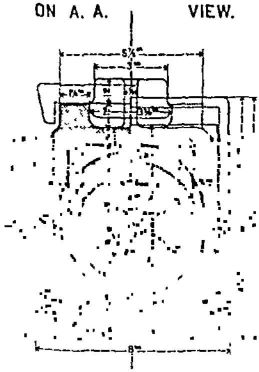
FOR

4½ IN JOURNAL.

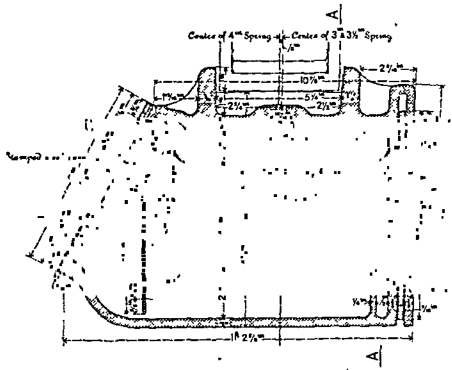
5 FT 6 IN GAUGE.

Scale — 3 inches to 1 foot

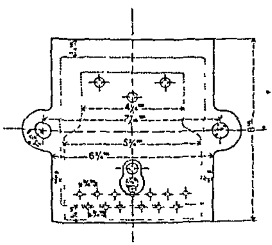
HALF SECTION ON A. A. HALF BACK VIEW.



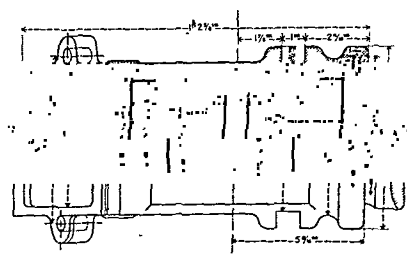
SECTION ON B. B.



STAMPED STEEL COVER.



HALF SECTIONAL PLAN ON C. C.



HALF TOP PLAN.

SUBJECT 7c.

PRESSED STEEL AXLE BOX.

METRE GAUGE.

Scale – 3 inches to 1 foot

FIG. 1.

HALF SECTION ON A. B. | HALF BACK ELEVATION.

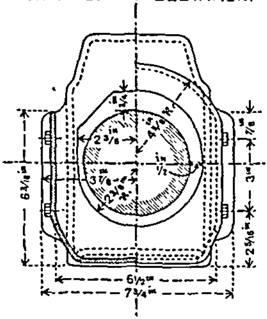


FIG. 2.

SECTION ON C. D.

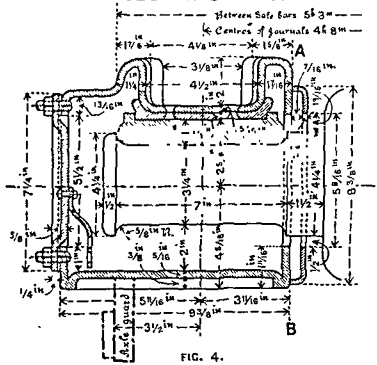


FIG. 3.

HALF FRONT ELEVATION. | HALF SECTION ON E. F.

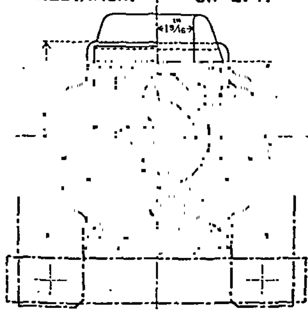


FIG. 4.

SIDE ELEVATION.

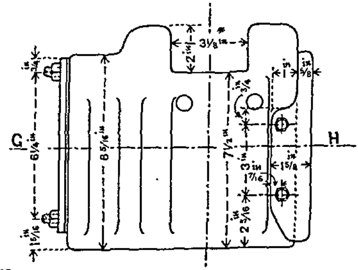


FIG. 6.

END VIEW.

OF GUN METAL BEARING.

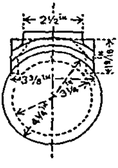
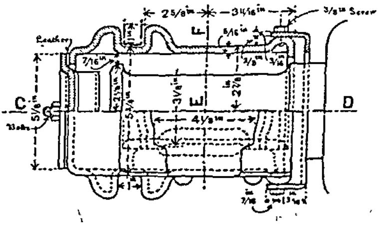


FIG. 5.

HALF SECTIONAL PLAN ON G. H.

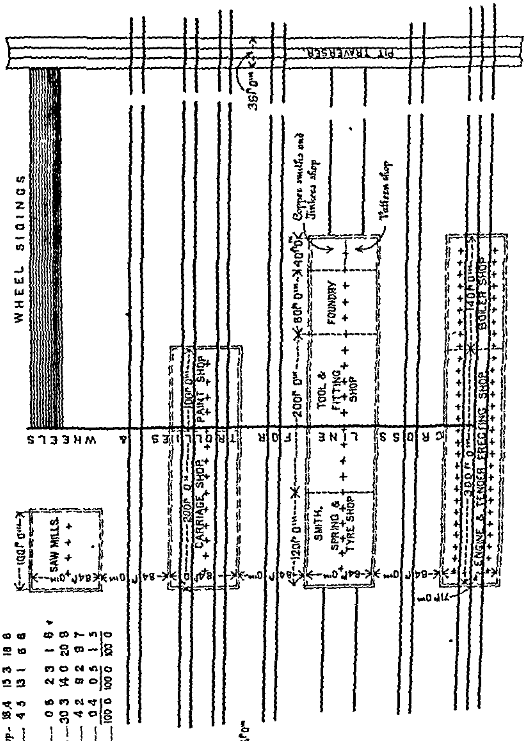


SUBJECT 15.

BLOCK PLAN OF WORKSHOPS FOR REPAIRING 10 ENGINES & 100 VEHICLES AT ONE TIME. METRE GAUGE.

APPROVED DESIGN.

Scale 120 feet to 1 inch



Percentage of total area occupied by each shop

Description	S.I.R	S.M.R	Proposed Standard
Saw mills	7 5	7 9	8 3
Carriage shop	18 1	19 9	16 6
Paint shop	7 3	7 7	8 3
Smithy	8 5	10 1	9 9
Tool & Fitting shop	18.4	15 3	18 8
Foundry	4 5	13 1	6 6
Copper smiths and Tinkers shop	0 6	2 3	1 6
Erecting shop	30 3	14 0	20 8
Boiler shop	4 2	8 2	8 7
Pattern shop	0 4	0 5	1 5
Total	100 0	100 0	100 0

PLATE XLVI.

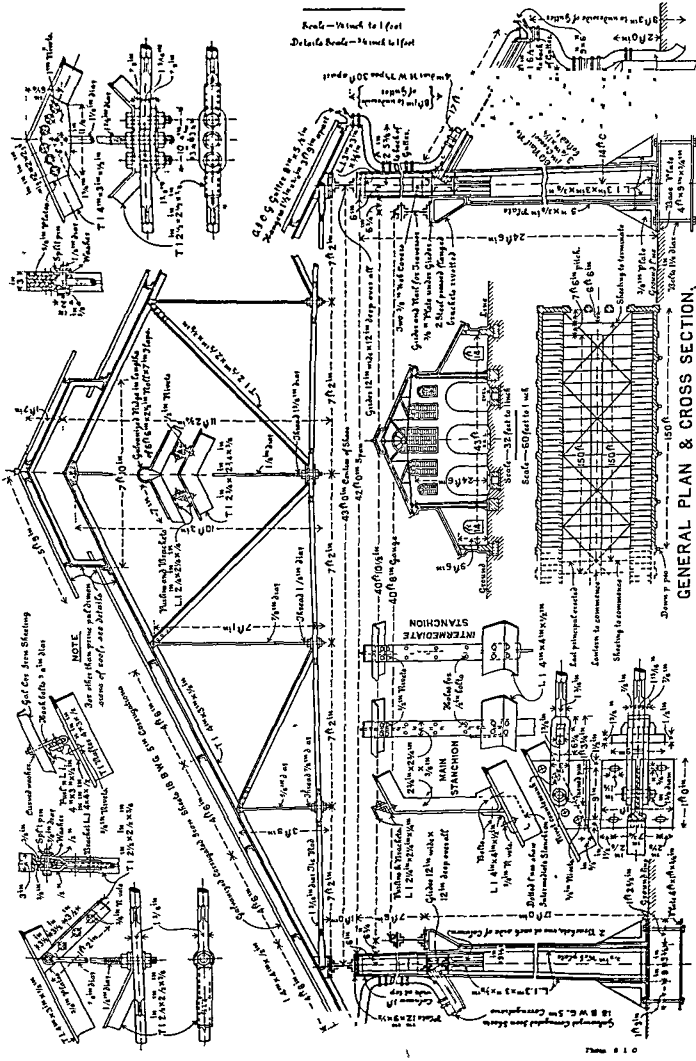
SUBJECT 15.

SECTION OF METRE GAUGE ERECTING SHOP.

S.I.R. NEGAPATAM

Scale—½ inch to 1 foot

Details Scale—¾ inch to 1 foot



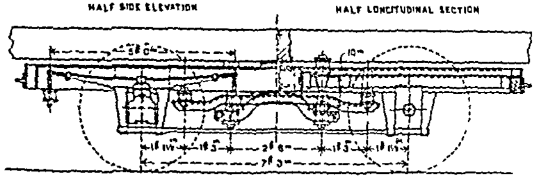
SUBJECT 6B. BOGIE TRUCKS. PLATE XLVII.

ADLER'S PATENT.

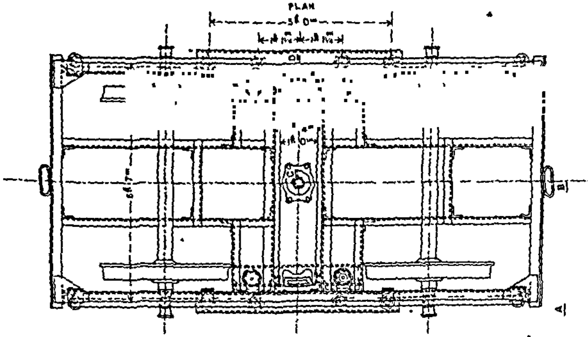
See Notes and Correspondence, Pages 161 to 163

L. & Y. Ry. 4 Ft. 8½ In. GAUGE.

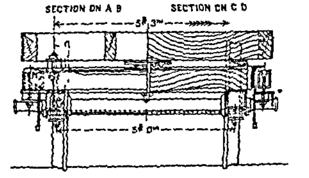
HALF SIDE ELEVATION HALF LONGITUDINAL SECTION



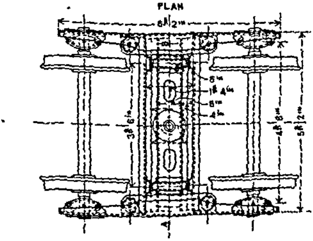
PLAN



SECTION ON A B SECTION ON C D

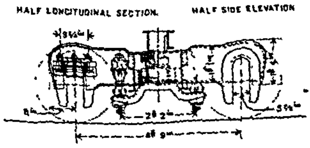


PLAN



ADLER'S PATENT.
APPLIED TO FOX'S PRESSED FRAME.
METRE GAUGE.

HALF LONGITUDINAL SECTION. HALF SIDE ELEVATION



END ELEVATION. SECTION ON A B

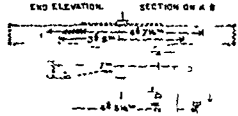


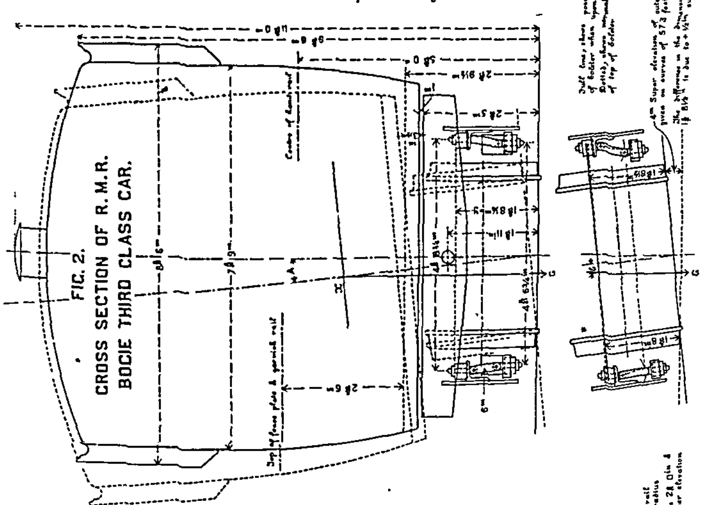
PLATE XLVIII.

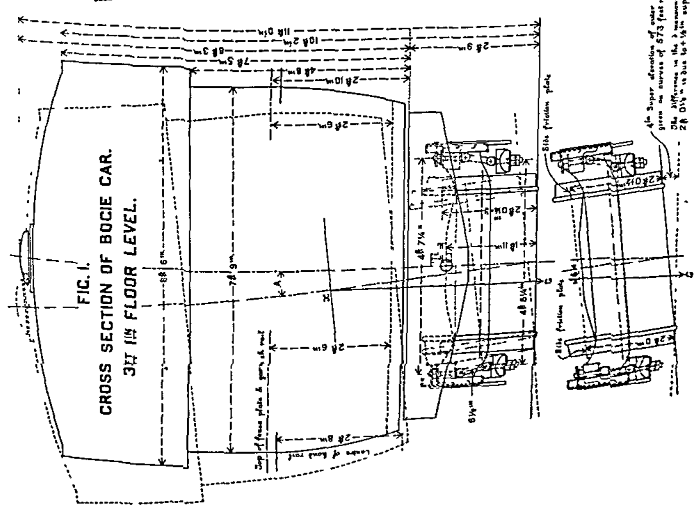
POSITION OF SWING LINKS IN ADLER'S BOGIE.

UPON CURVE OF 573 FEET RADIUS.

METRE GAUGE.

See Notes and Correspondence, Pages 161 to 163





SUBJECT 7C.

See Notes and Correspondence, Pages 179 to 184

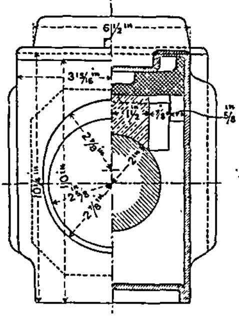
STAMPED STEEL AXLE BOX.

5 FT 6 IN GAUGE.

Scale — 3 inches to 1 foot.

FIG. 1.

HALF BACK ELEVATION. HALF SECTION ON A. B.



LONGITUDINAL SECTION.

FIG. 2.

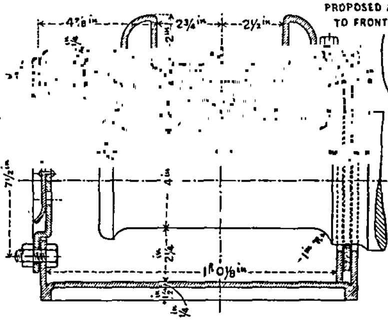


FIG. 2A

PART SECTION SHOWING PROPOSED ALTERATION TO FRONT OF BOX.

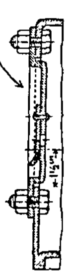


FIG. 3.

VIEW SHOWING LOCATION OF FRACTURE.

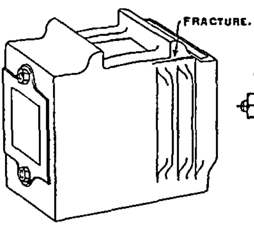
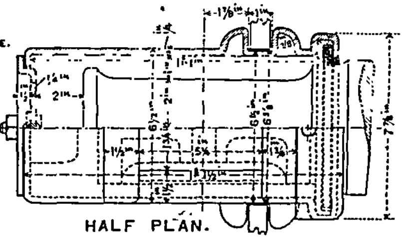


FIG. 4.

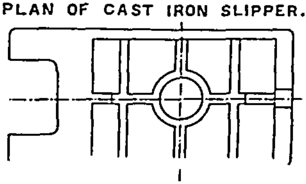
HALF SECTION ON C. D.



HALF PLAN.

FIG. 5.

PLAN OF CAST IRON SLIPPER.



SUBJECT 7C.

See Notes and Correspondence, Pages 179 to 184.

CAST STEEL AXLE BOX.

FOR 9in X 4in & 9in X 4½in JOURNALS.

5ft 6in GAUGE.

Scale—3 inches to 1 foot.

FIG. 1.

CROSS SECTION.

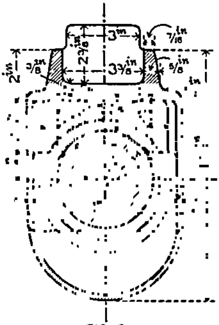


FIG. 2.

LONGITUDINAL SECTION.

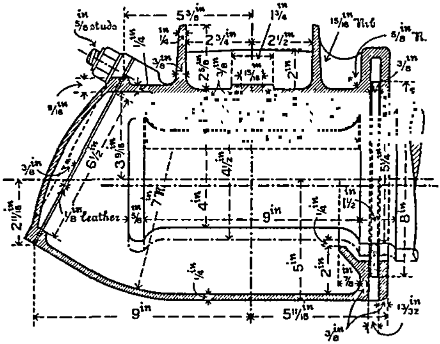


FIG. 3.

BACK ELEVATION.

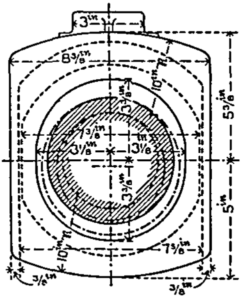
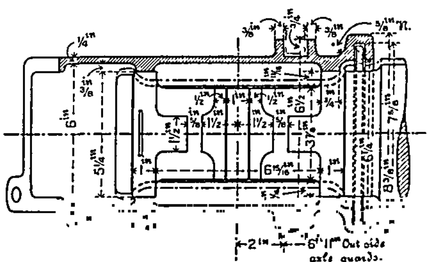


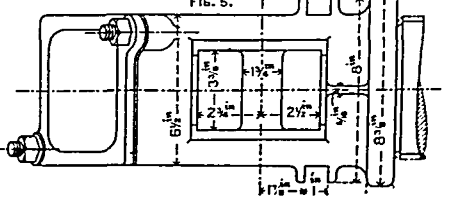
FIG. 4.

SECTIONAL PLAN.



PLAN

FIG. 5.



NOTE

For 9in x 4in Journals.

The depth from centre of journal to bottom of box is 4½in, the total depth of box from bearing spring seating to bottom is 9¾in.

The bearing brass is ½in narrower (3⅛in against 3⅝in) and ⅛in shallower (2in against 2⅛in)

The dustshield is also ⅛in narrower (7¼in against 7⅜in).

See Notes and Correspondence, Pages 198 to 214

SUBJECT 15.

BLOCK PLAN OF S. M. R. WORKSHOPS HUBLI.

Scale—120 feet to 1 inch

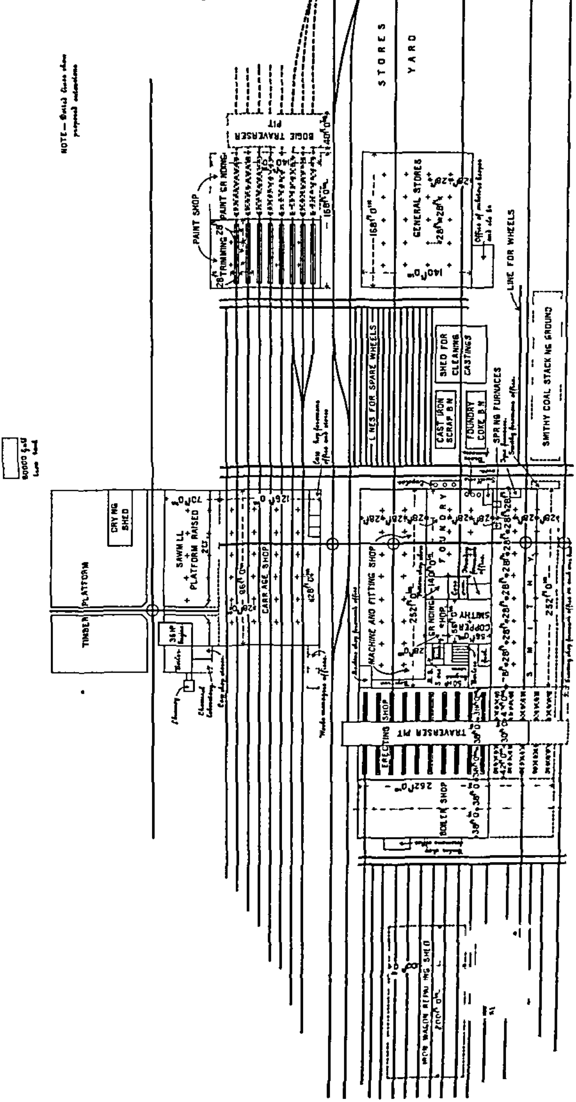


PLATE LII.

See Notes and Correspondence Pages 215 to 222

SUBJECT 15.

OF S. I. R. WORKSHOPS NEGAPATAM.

Scale — 120 feet to 1 inch

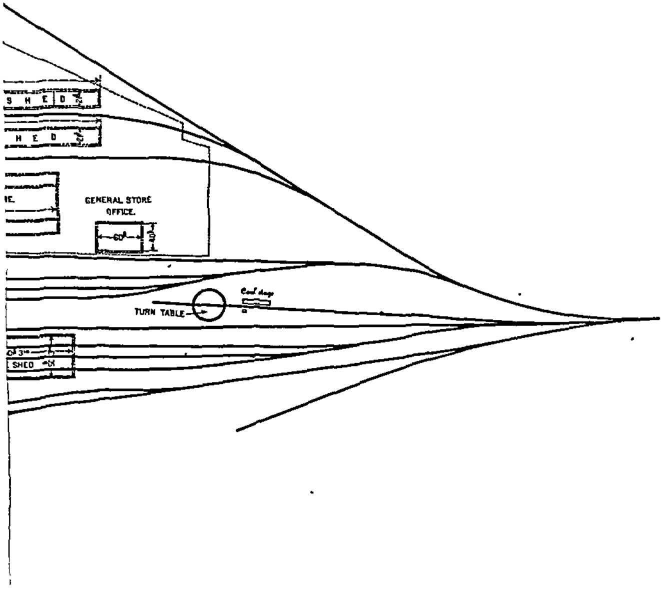
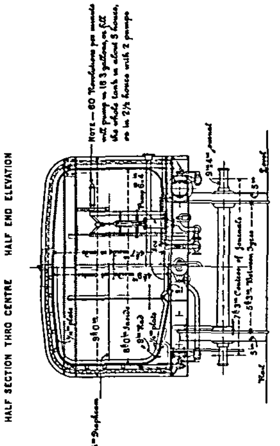


PLATE LIII.

See Notes and Correspondence, Page 225



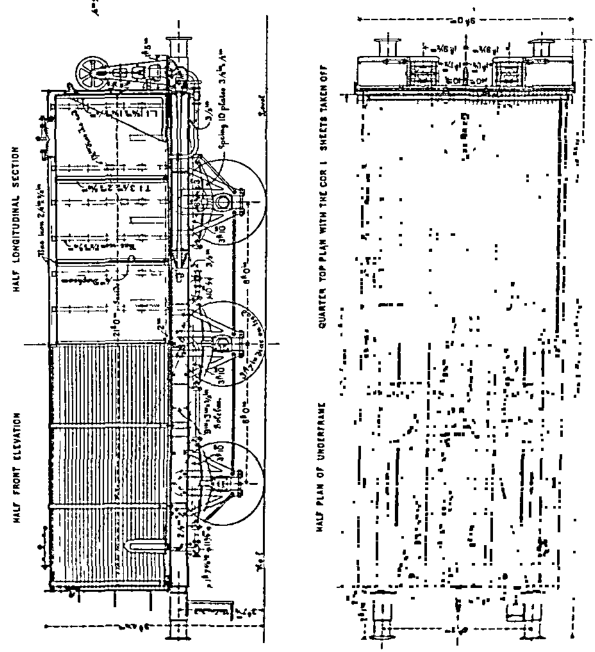
SUBJECT 5A. E. B. S. R.

TANK WAGON.

TO HOLD 17 TONS KEROSINE OIL IN BULK.

5FT 6IN GAUGE.

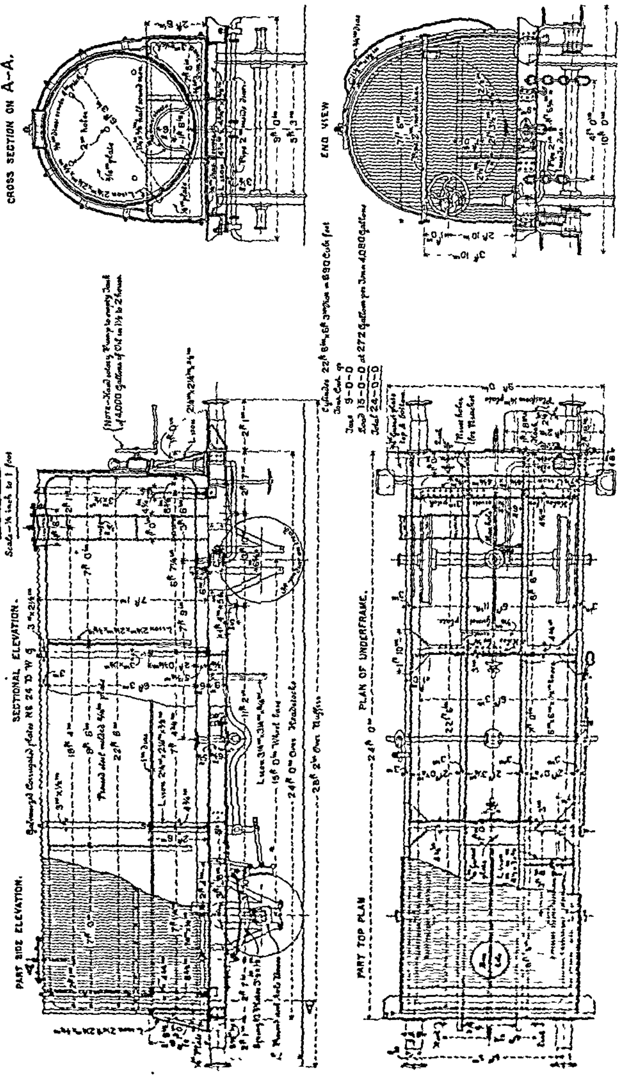
Scale — 1/2 inch to 1 foot



See Notes and Correspondence, Page 226

SUBJECT 5A. E. I. R. PEARCE'S 24 FEET TANK WAGON.

TO HOLD 15 TONS MINERAL OIL IN BULK. 5FT 6IN GAUGE.

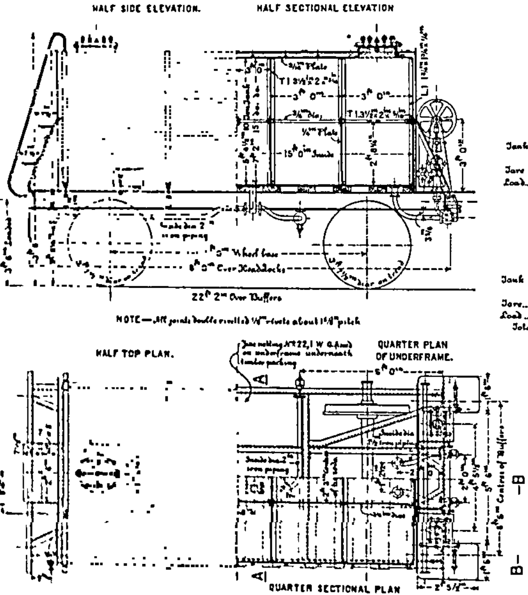


See Notes and Correspondence, Page 227.

SUBJECT 5A. M. R. C. TANK WAGONS.

TO HOLD EITHER 15 TONS, OR 11 TONS, OIL IN BULK. 5FT 6IN GAUGE.

Scale—¼ inch to 1 foot



LARGE WAGON

Tank 15 ft 0 in x 7 ft 1 in x 7 ft 2 in = 673 Cub ft = 4095 gallˢ capacity

	Tons.	Cwt.	qr.	
Tare (approx.)	9	0	0	
Load	15	0	0	at 273 gallˢ per ton.
Total	24	0	0	

SMALL WAGON

Tank 15 ft 0 in x 7 ft 1 in x 5 ft 4½ in = 481·25 Cub ft = 3003 gallˢ capacity

	Tons.	Cwt.	qr.	
Tare	8	3	2	
Load	11	0	0	at 273 gallˢ per ton.
Total	19	3	2	

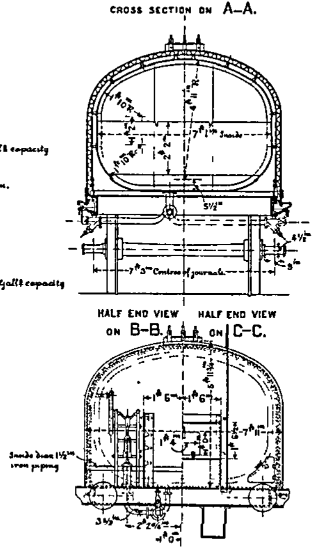


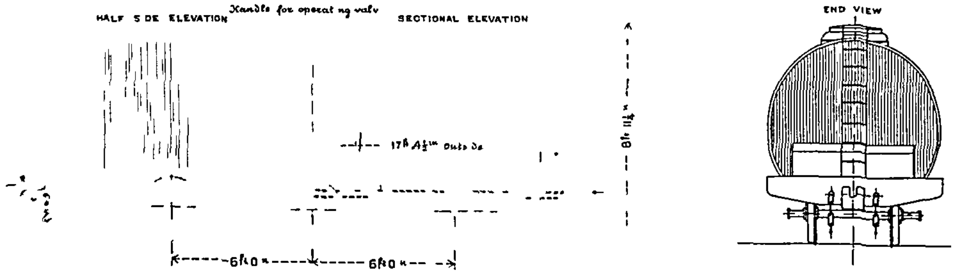
PLATE LVI.

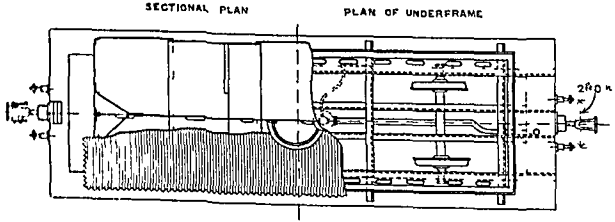
See Notes and Correspondence Page 228

SUBJECT 5A. S. I R. TANK WAGON.

TO HOLD 10 TONS PETROLIUM OIL IN BULK METRE GAUGE

Scale—¼ inch = 1 foot





LENGTH	
Over buffers	25ft 0⅞in
Outside body	17ft 9½in
Underframe	21ft 5in
Wheel base	12ft 0in
HEIGHT ABOVE RAIL LEVEL	
Top of underframe mean height	2ft 8in
WEIGHTS	
Gross weight fully loaded tons	17 12 0 0
Weight of oil contained	10 0 0 0
Tare empty	7 12 0 0
Weight per foot run over buffers	7 tons

THE COUNTERBALANCING OF LOCOMOTIVES.

SHOWING DIAGRAMS TAKEN IN THE ENGINEERING DEPARTMENT OF PURDUE UNIVERSITY.

Reprinted from "Engineering News" January 1885

FIG 1.

Shape of End of Test Wire.

FIG 2.

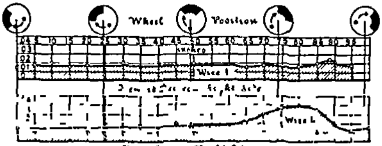
Weight with which each Driver presses on Rail when at Rest, 14,000 lbs.

Weights of Revolving and Reciprocating Parts of Purdue Locomotive

FIG 3.

Speed—58 3 miles per hour—312 revolutions per minute

Scale—{Length One division = 5 in. / Thickness One division = .01 in.



Rear Driver—Right Side

FIG 4.

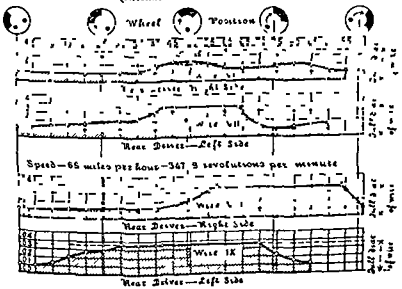
Scale—{Length One division = 5 in. / Thickness One division = .01 in.

Rear Driver—Right Side Speed—65 miles per hour—347 9 rev. per min.

FIG 5.

Speed—58 miles per hour—310 5 revolutions per minute

Scale—{Length One division = 5 in. / Thickness One division = .01 in.



Rear Driver—Left Side

FIG 6.

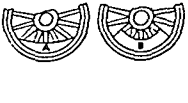


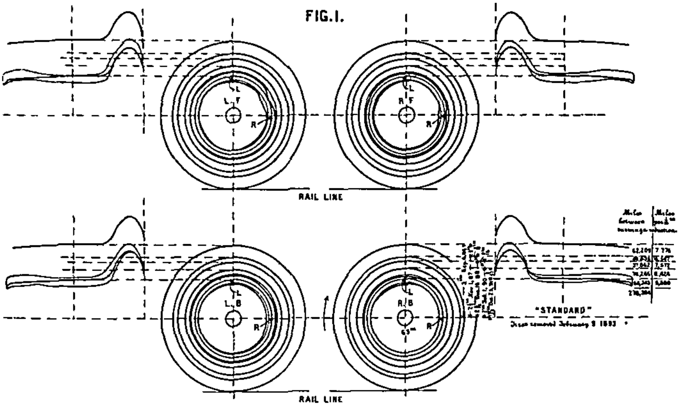
DIAGRAM OF TIRE WEAR.

4 COUPLED 8 WHEELED PASSENGER ENGINES.

(Reprinted by permission from the Proceedings, American Ry M M Association 1895.)

C B. & N ENGINE No 6.

FIG. 1.



C B & N ENGINE No 11

FIG. 2.

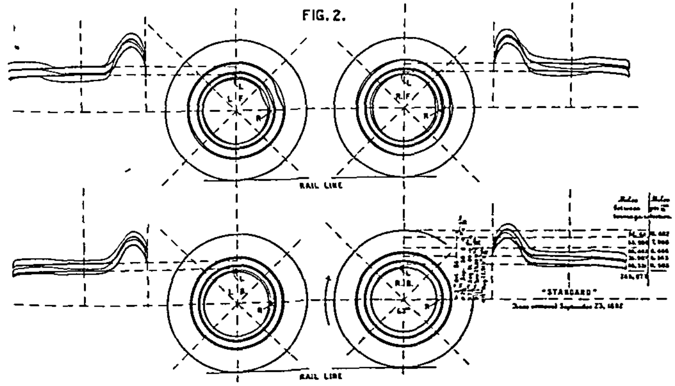


PLATE LX.

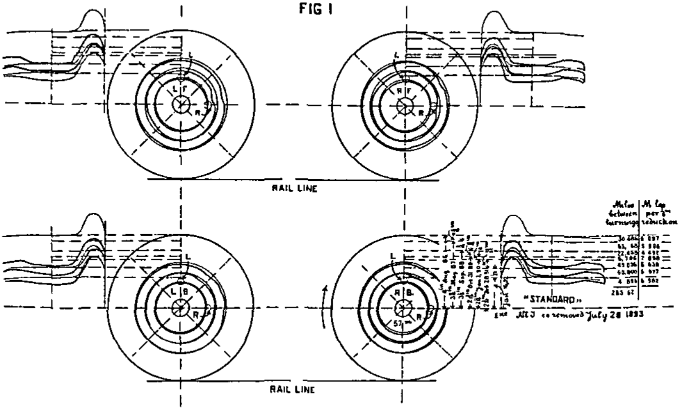
DIAGRAM OF TIRE WEAR.

4 COUPLED 8 WHEELED FREIGHT ENGINES.

(Reprinted by permission from the Proceedings, American Ry M M Association 1895)

C. B. & N. ENGINE No. 65

FIG 1



C. B. & N. ENGINE No. 69.

FIG 2

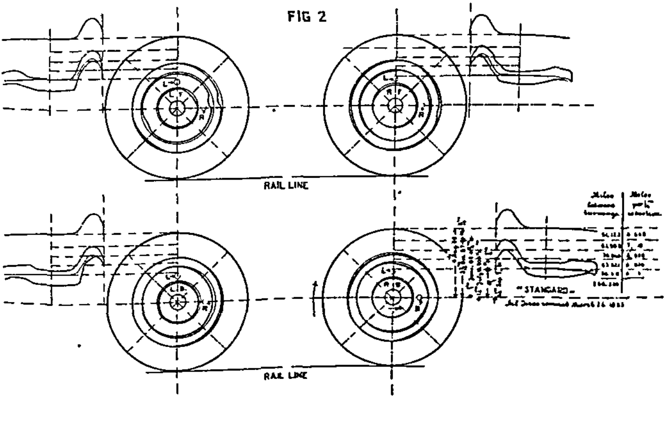


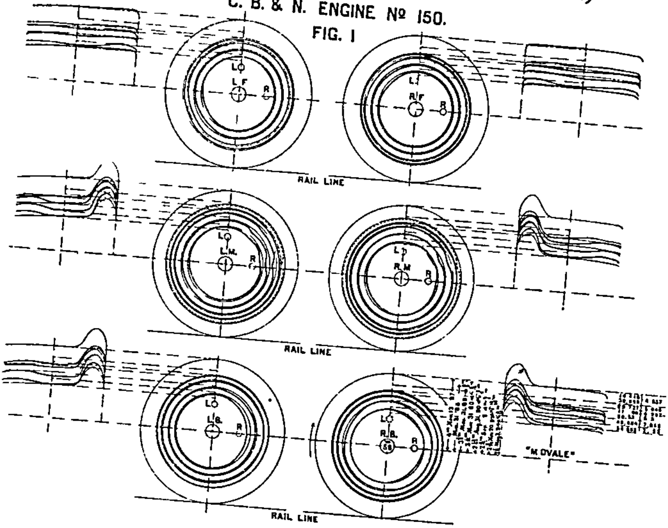
DIAGRAM OF TIRE WEAR.

6 COUPLED 10 WHEELED ENGINES.

(*Reprinted by permission from the Proceedings, American Ry. M.M. Association 1895*)

C. B. & N. ENGINE No 150.

FIG. 1



C. B. & N. ENGINE No 154.

FIG. 2

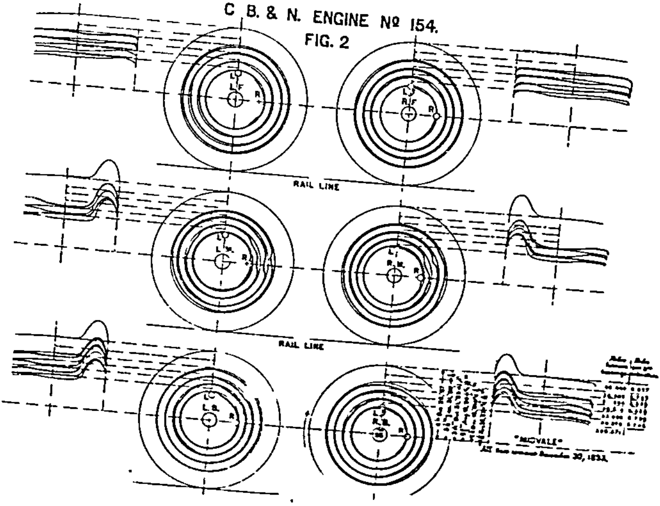


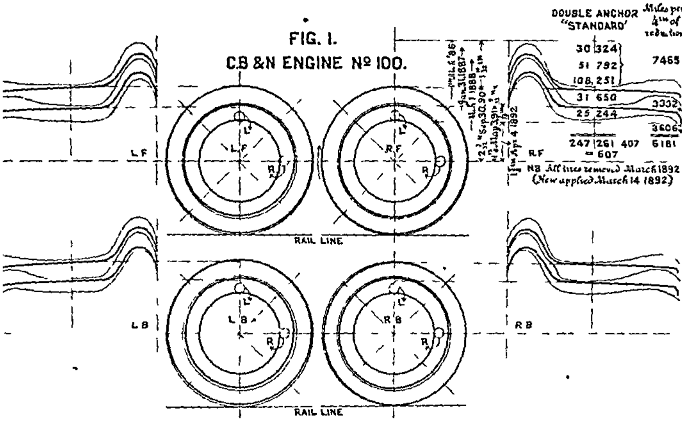
DIAGRAM OF TIRE WEAR.

4 WHEELED SWITCHING ENGINES, ALL COUPLED.

(*Reprinted by permission from the Proceedings, American Ry M M Association 1895*)

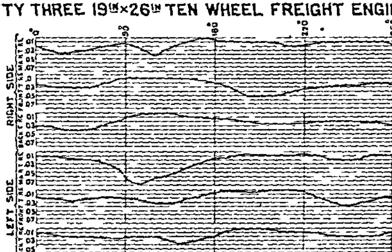
FIG. 1.

C.B & N ENGINE Nº 100.



AVERAGE OF IRREGULARITIES IN WEAR OF TIRES OF FIFTY THREE 19IN×26IN TEN WHEEL FREIGHT ENGINES.

FIG 2



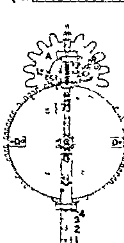


FIG.3.

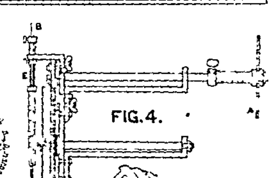


FIG.4.

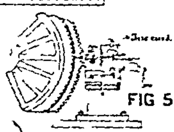


FIG 5.

PLATE LXIII

WEAR OF DRIVING WHEELS.

4 COUPLED 8 WHEELED PASSENGER ENGINE.

(Reprinted by permission from the Proceedings, American Ry M M Association 1895.)

PRESSURE OF EACH WHEEL ON RAIL. ENGINE JUST STARTING.

RIGHT SIDE

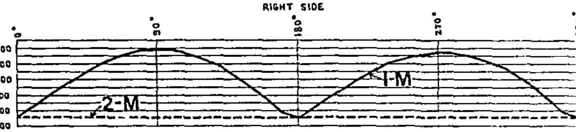


FIG. 1.

LEFT SIDE.

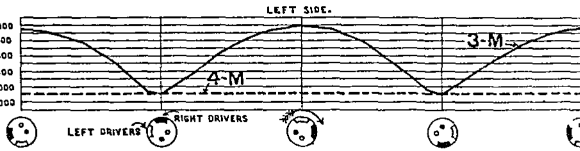


FIG. 2.

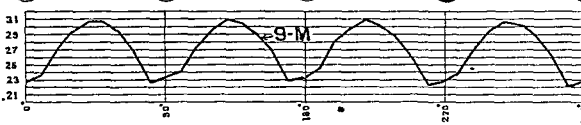


FIG. 3.

CURVE OF COEFFICIENT OF SLIP. ENGINE JUST STARTING.

CURVE OF TOTAL PRESSURE ON RAIL. ENGINE JUST STARTING.
ALL DRIVERS.

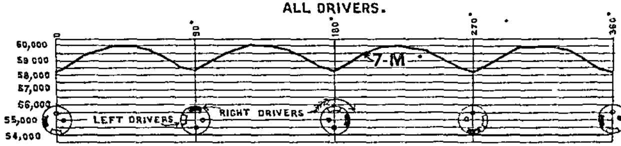


FIG. 4.

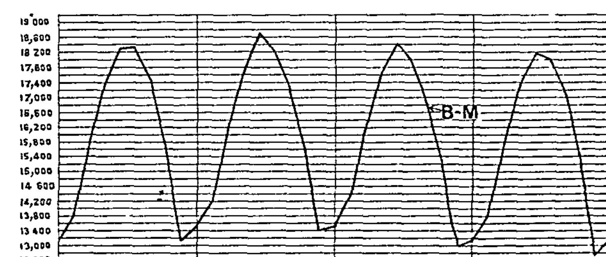


FIG. 5.

CURVE OF TOTAL ROTATIVE FORCE AT RAIL. ENGINE JUST STARTING.

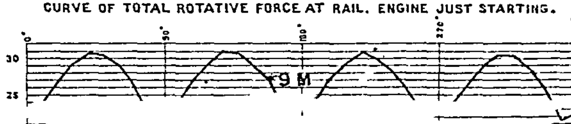


FIG. 6.

CURVE OF COEF SLIP. ENGINE JUST STARTING.

PLATE LXIV

WEAR OF DRIVING WHEELS.

4 COUPLED 8 WHEELED PASSENGER ENGINE.

(Reprinted by permission from the Proceedings American Ry. M M Association 1895)

PRESSURE OF EACH WHEEL ON RAIL, AT 40 MILES PER HOUR.

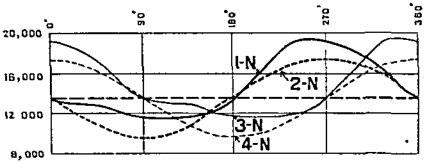


FIG. I

Right side { Front wheel / Back „

Left side { Front „ / Back „

CURVE OF TOTAL PRESSURE ON RAIL, AT 40 MILES PER HOUR ALL DRIVERS.

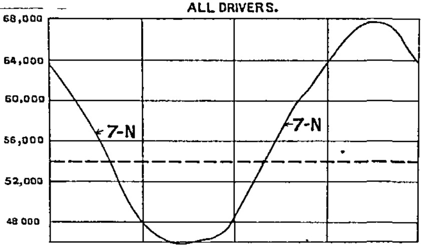


FIG. 2.

CURVE OF TOTAL ROTATIVE FORCE AT RAIL.

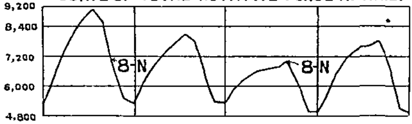


FIG. 3

CURVE OF COEFFICIENT OF SLIP.

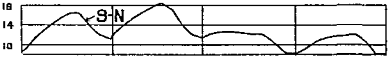


FIG 4.

WEAR OF TIRES.

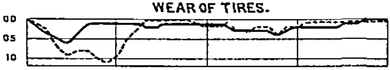


FIG. 5.

Right side { Front wheel / Back „

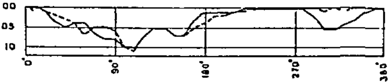


FIG. 6.

Left side { Front wheel. / Back

WEAR OF DRIVING WHEELS.

4 COUPLED 8 WHEELED PASSENGER ENGINE.

(Reprinted by permission from the Proceedings, American Ry. M. M. Association 1895.)

PRESSURE OF EACH WHEEL ON RAIL, AT 60 MILES PER HOUR.

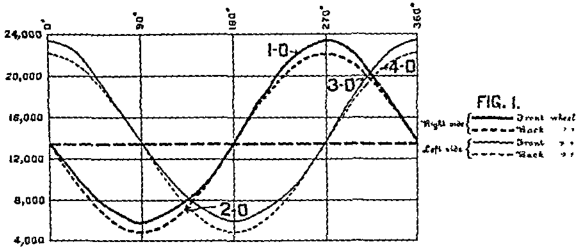


FIG. 1.

CURVE OF TOTAL PRESSURE ON RAIL, AT 60 MILES PER HOUR
ALL DRIVERS.

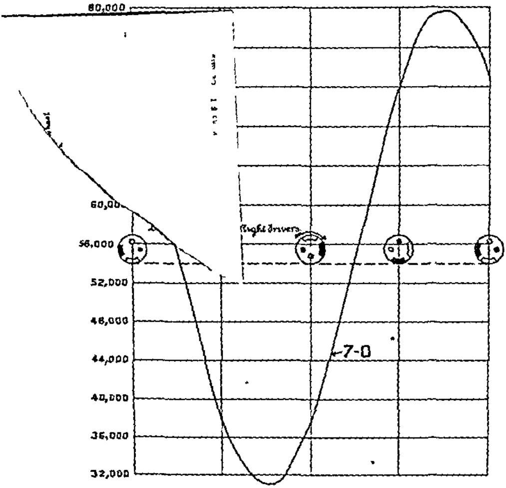


FIG. 2.

CURVE OF TOTAL ROTATIVE FORCE OF RAIL.

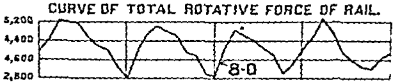


FIG. 3.

CURVE OF COEFFICIENT OF SLIP.

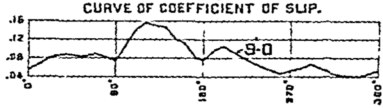


FIG. 4.

WEAR OF DRIVING WHEELS.

19 × 26 TEN WHEELED SIX COUPLED ENGINE.

(Reprinted by permission from the Proceedings American Ry M M Association, 1895.)

PRESSURE OF EACH WHEEL ON RAIL, ENGINE JUST STARTING.

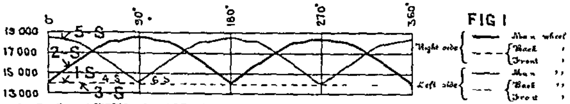


FIG 1

CURVE OF TOTAL PRESSURE ON RAIL, ENGINE JUST STARTING ALL DRIVERS.

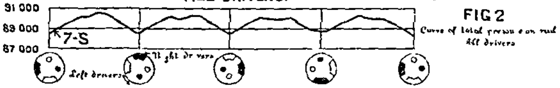


FIG 2 Curve of total pressure on rail All drivers

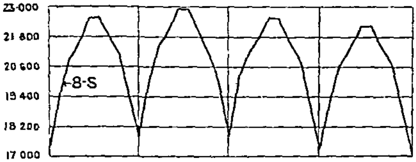
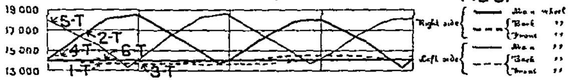


FIG 3. Curve of total rotative force at rail.

FIG. 4. Curve of coefficient of slip

PRESSURE OF EACH WHEEL ON RAIL, AT 10 MILES PER HOUR.

FIG 5.



CURVE OF TOTAL PRESSURE ON RAIL, AT 10 MILES PER HOUR. ALL DRIVERS.

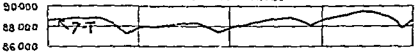


FIG. 6. Curve of total pressure on rail All drivers

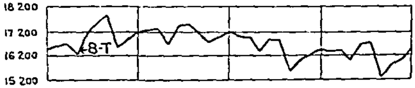


FIG 7. Curve of total rotative force at rail

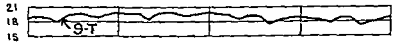


FIG. 8. Curve of coefficient of slip

FIG. 9.

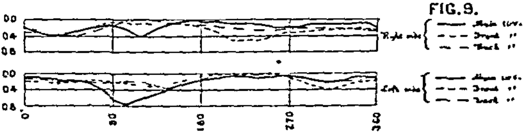


PLATE LXVI.

WEAR OF DRIVING WHEELS.

19 × 26 TEN WHEELED SIX COUPLED ENGINE.

(Reprinted by permission from the Proceedings, American Ry M M Association, 1895)

PRESSURE OF EACH WHEEL ON RAIL, ENGINE JUST STARTING.

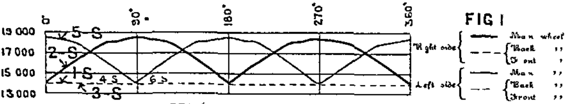


FIG 1

CURVE OF TOTAL PRESSURE ON RAIL, ENGINE JUST STARTING ALL DRIVERS.

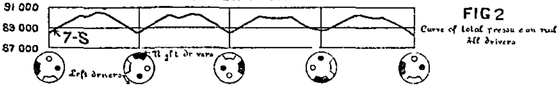


FIG 2

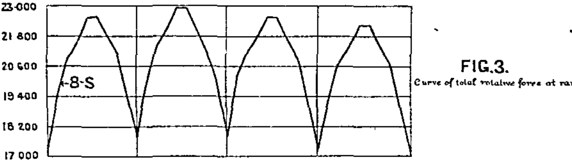


FIG. 3.

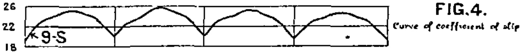
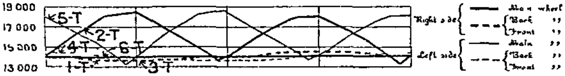


FIG. 4.

PRESSURE OF EACH WHEEL ON RAIL, AT 10 MILES PER HOUR. FIG 5.



CURVE OF TOTAL PRESSURE ON RAIL, AT 10 MILES PER HOUR. ALL DRIVERS.

FIG. 6.

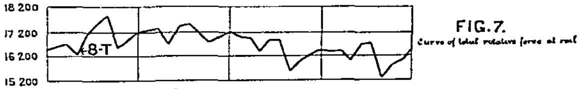


FIG. 7.

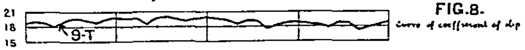


FIG. 8.

FIG. 9.

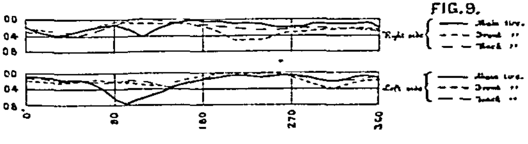


PLATE LXVII.

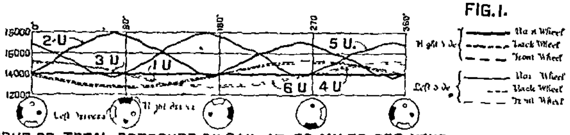
WEAR OF DRIVING WHEELS.

19 X 26 TEN WHEELED SIX COUPLED ENGINE.

(Reprinted by permission from the Proceedings, American Ry M M Association, 1895)

PRESSURE OF EACH WHEEL ON RAIL AT 20 MILES PER HOUR

FIG. I.



CURVE OF TOTAL PRESSURE ON RAIL, AT 20 MILES PER HOUR ALL DRIVERS.

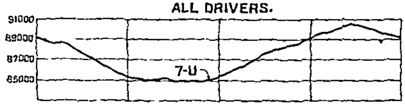


FIG. 2.

Curve of total pressure on rail All drivers

FIG. 3.

Curve of total rotative force at rail

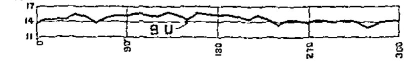
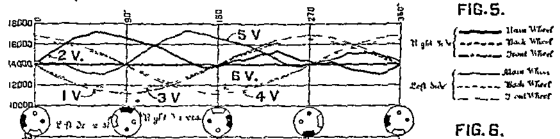


FIG. 4.

Curve of coefficient of slip

PRESSURE OF EACH WHEEL ON RAIL AT 30 MILES PER HOUR

FIG. 5.



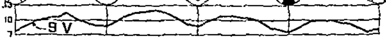


FIG. 6.

Curve of coefficient of slip

CURVE OF TOTAL PRESSURE ON RAIL, AT 30 MILES PER HOUR ALL DRIVERS

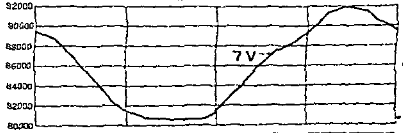


FIG. 7.

Curve of total pressure on rail All drivers

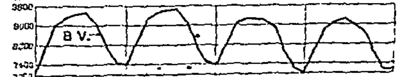


FIG. 8.

Curve of total rotative force at rail

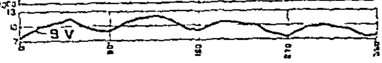


FIG 9.

Curve of coefficient of slip

PLATE LXVIII.

WEAR OF DRIVING WHEELS.

19 X 26 TEN WHEELED SIX COUPLED ENGINE.

(Reprinted by permission from the Proceedings, American Ry M M Association, 1895)

PRESSURE OF EACH WHEEL ON RAIL, AT 40 MILES PER HOUR

RIGHT SIDE

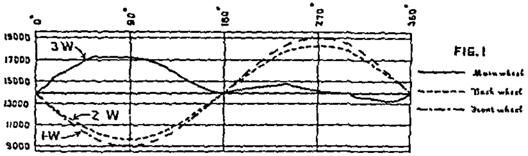


FIG. 1

LEFT SIDE.

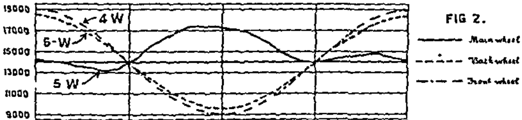


FIG 2.

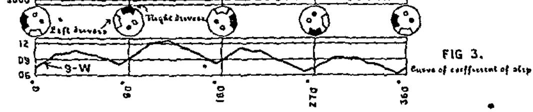


FIG 3.

CURVE OF TOTAL PRESSURE ON RAIL, AT 40 MILES PER HOUR.

ALL DRIVERS.

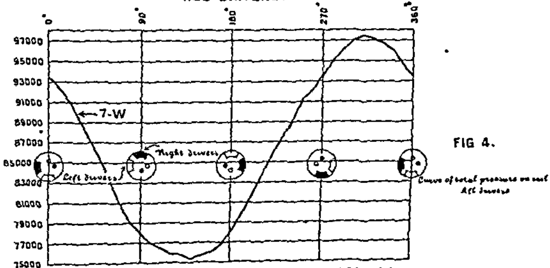


FIG 4.

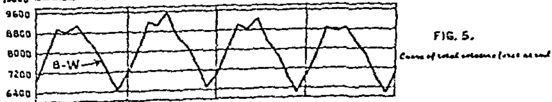


FIG. 5.

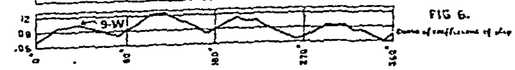


FIG 6.

INTERNATIONAL RAILWAY CONGRESS LONDON 1895.

DIAGRAMS SHOWING GENERAL PARTICULARS OF DIMENSIONS AND PERFORMANCE OF EXPRESS LOCOMOTIVES.

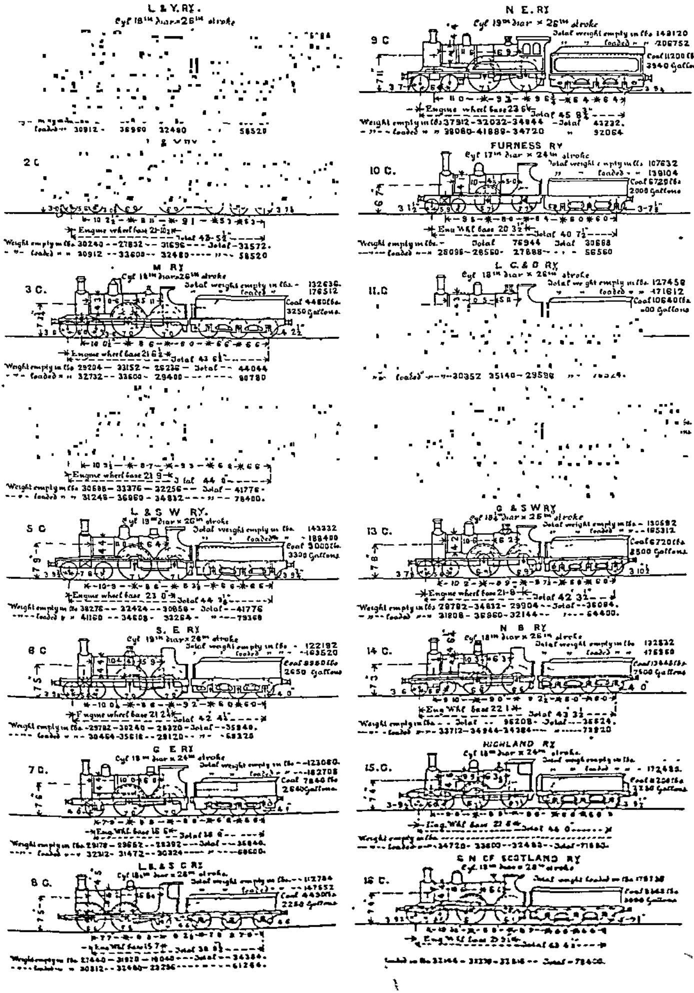
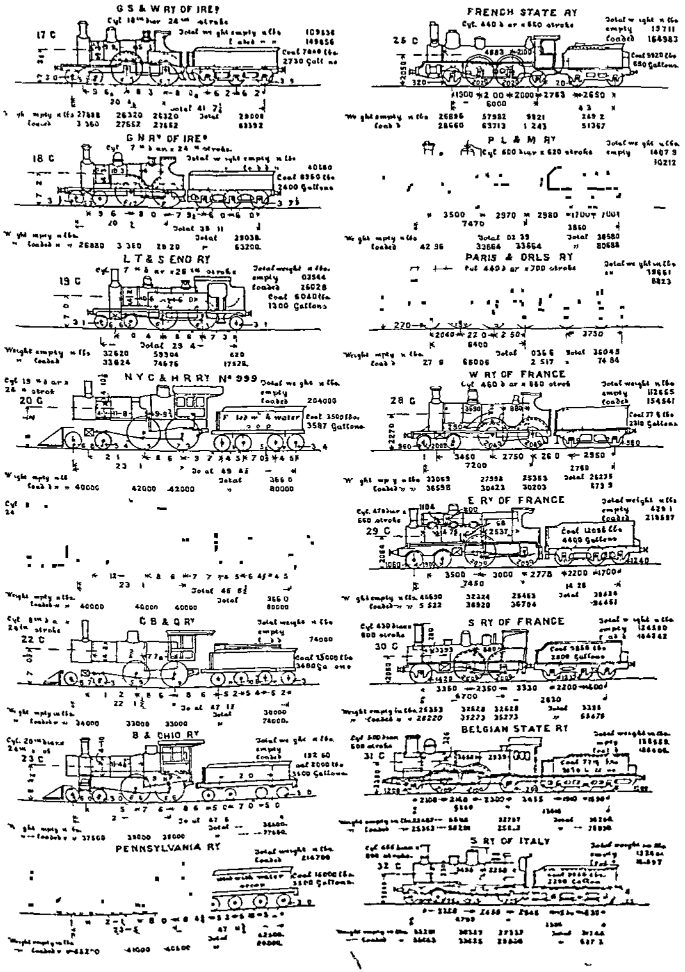


PLATE LXX.

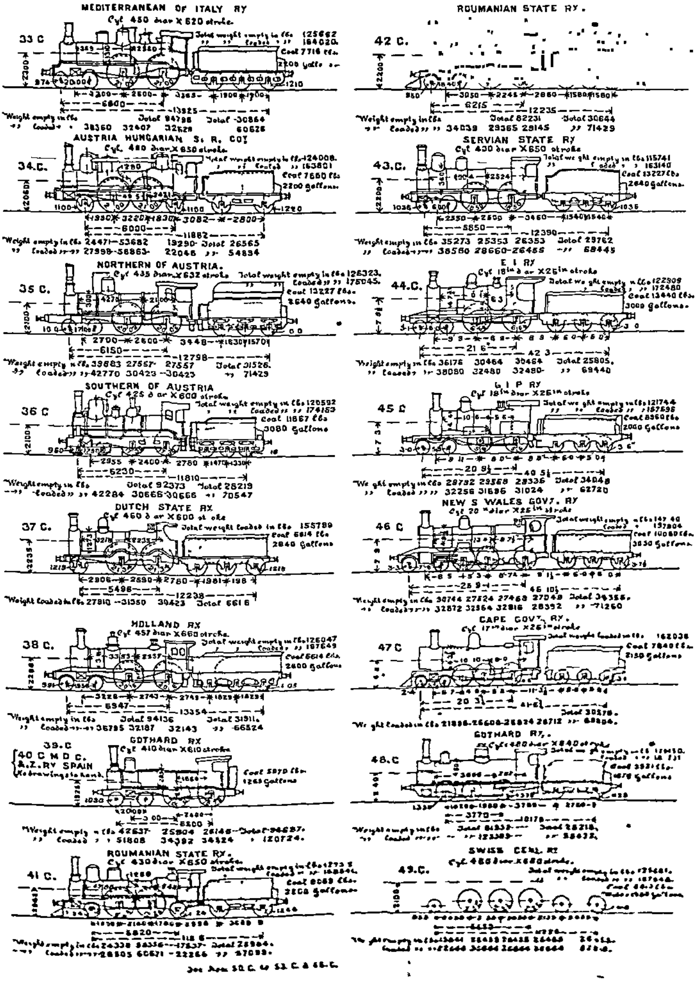
INTERNATIONAL RAILWAY CONGRESS LONDON 1895.

DIAGRAMS SHOWING GENERAL PARTICULARS OF DIMENSIONS AND PERFORMANCE OF EXPRESS LOCOMOTIVES.



INTERNATIONAL RAILWAY CONGRESS LONDON 1895.

DIAGRAMS SHOWING GENERAL PARTICULARS OF DIMENSIONS AND PERFORMANCE OF EXPRESS LOCOMOTIVES.



INTERNATIONAL RAILWAY CONGRESS LONDON 1895.

DIAGRAMS SHOWING GENERAL PARTICULARS OF DIMENSIONS AND PERFORMANCE OF EXPRESS LOCOMOTIVES.

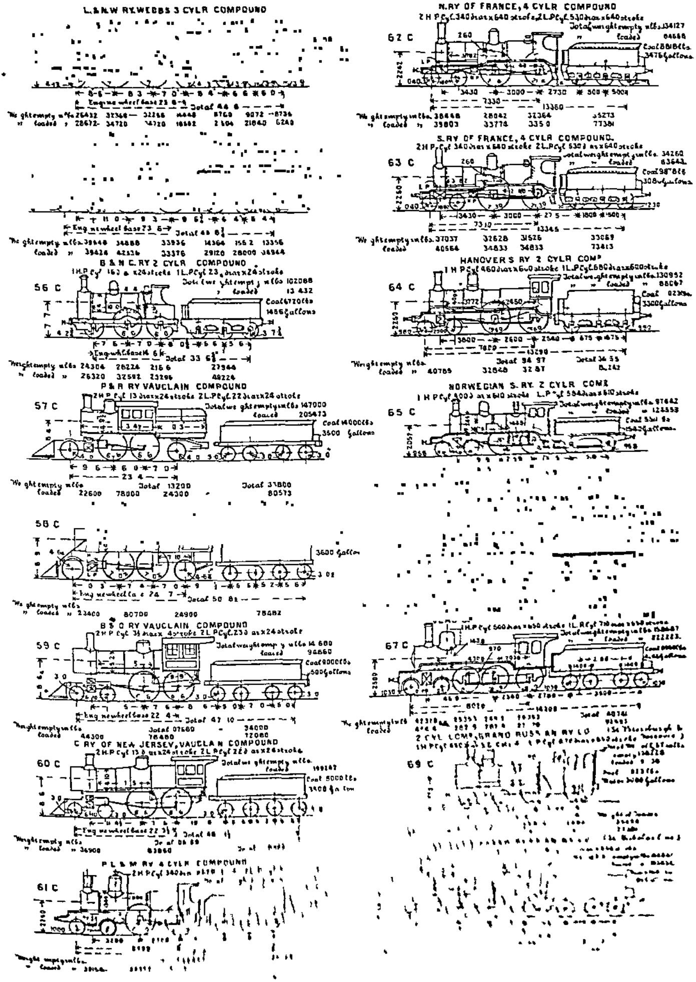
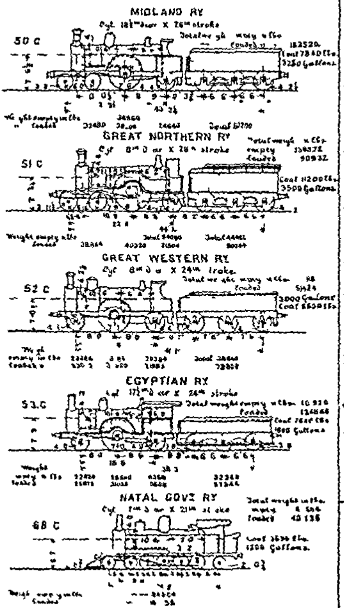


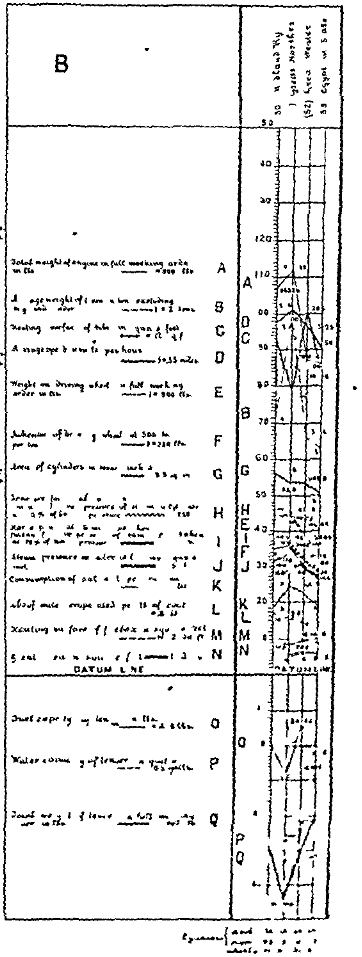
PLATE LXXIII.

INTERNATIONAL RAILWAY CONGRESS LONDON 1895.

DIAGRAMS SHOWING GENERAL PARTICULARS OF DIMENSIONS AND PERFORMANCE OF EXPRESS LOCOMOTIVES

SINGLE DRIVING. WHEEL ENGINES





INTERNATIONAL RAILWAY CONGRESS LONDON 1895.

DIAGRAMS SHOWING GENERAL PARTICULARS OF DIMENSIONS AND PERFORMANCE OF EXPRESS LOCOMOTIVES.

SINGLE DRIVING. WHEEL ENGINES.

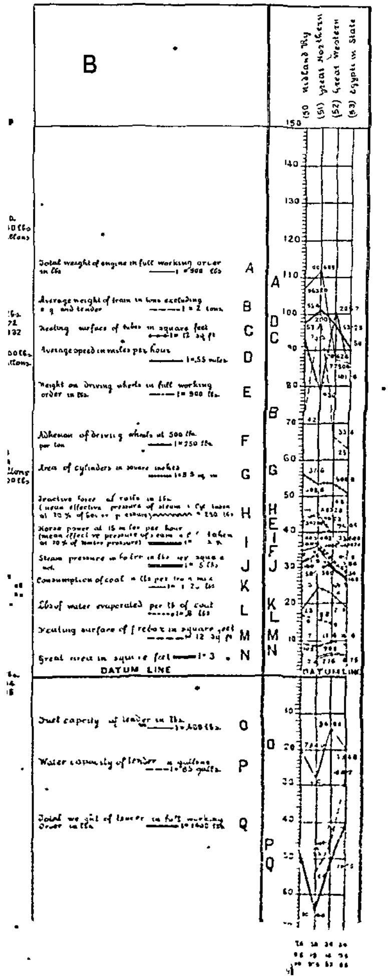
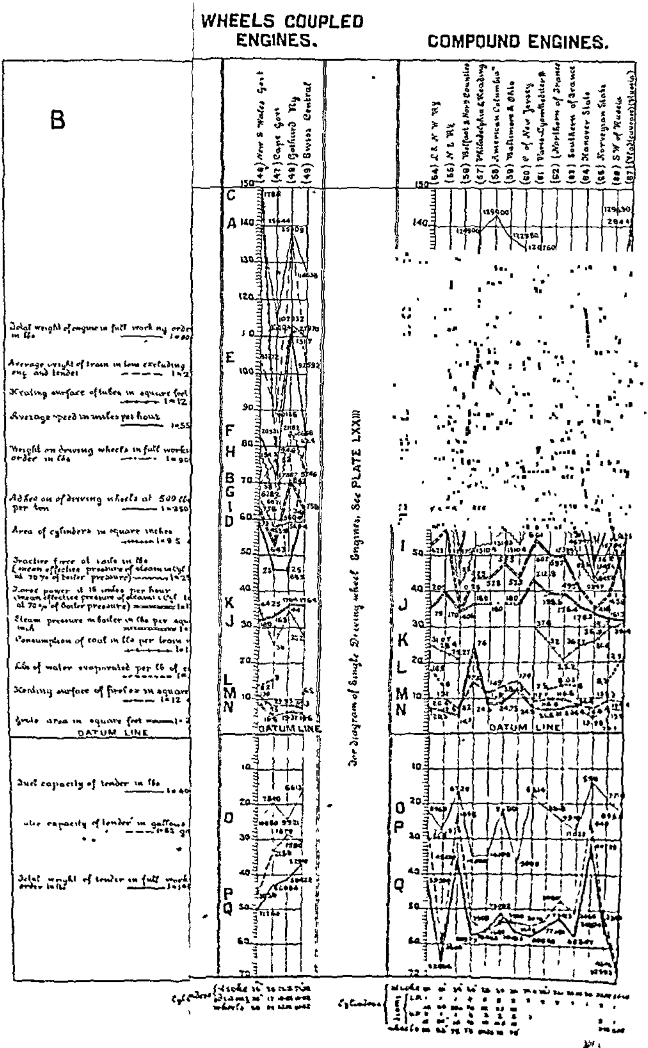


PLATE LXXIV.

1895.

OF EXPRESS LOCOMOTIVES.

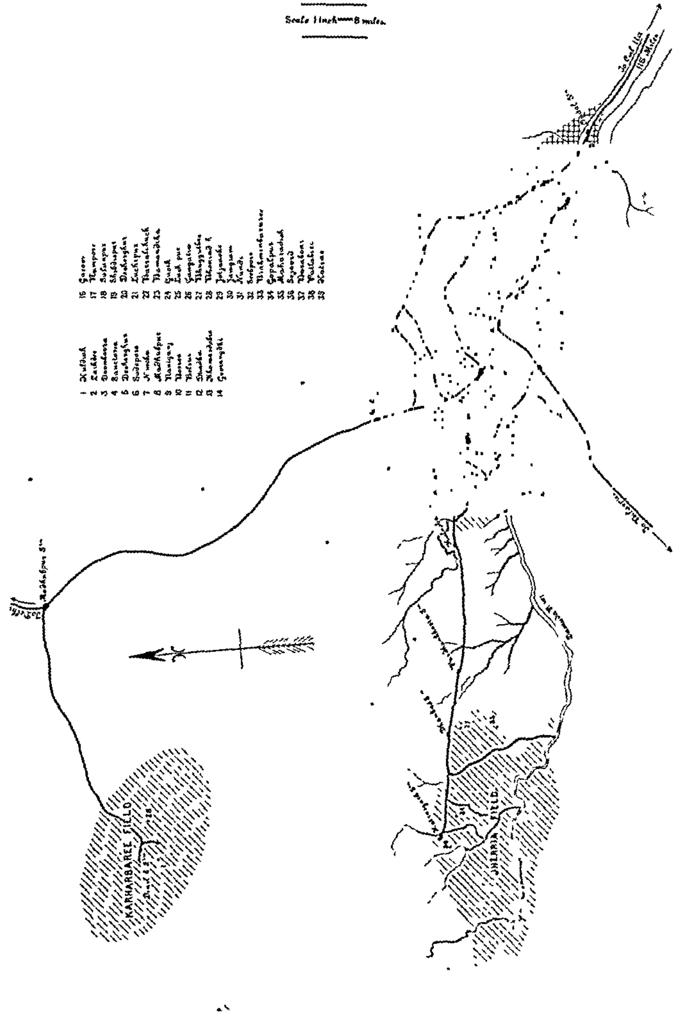


1895.

ɒF EXPRESS LOCOMOTIVES.

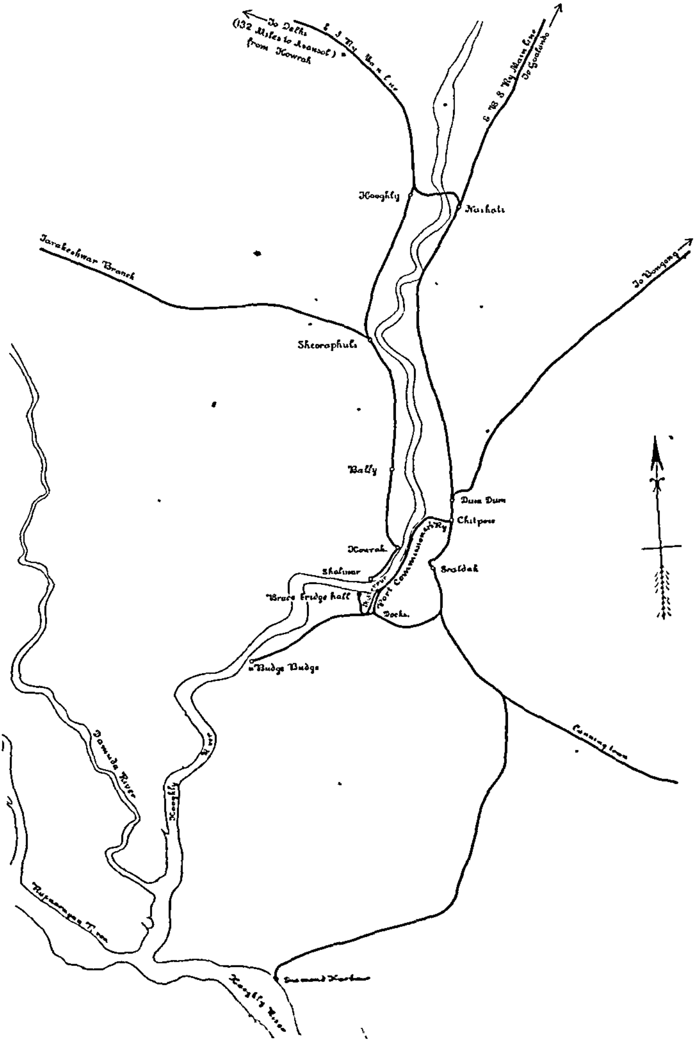
BENGAL COAL FIELDS.

Scale 1 Inch = 8 miles.



BENGAL COAL FIELDS.

Scale 1 inch = 6 miles



REPORT ON STEEL-TIRED WHEELS.

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LIMIT OF THICKNESS FOR TIRES.

FIG. 1.

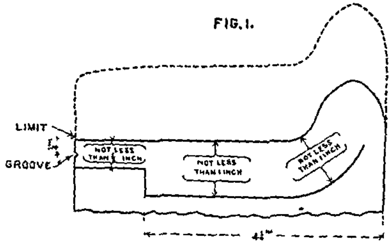
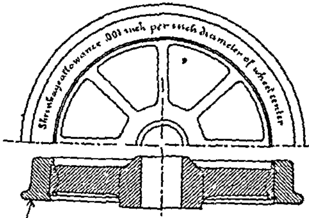


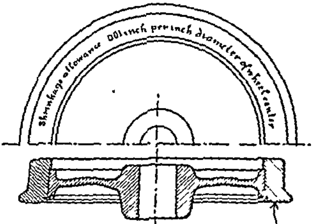
FIG 2.



PAGE, NEWELL & CO, BOSTON MASS.
ENGINE TRUCK WHEEL.
With wrought Iron Oval Spoke Center and Brunswick Tire Fastenings

Centers are also made with single rectangular spokes for engine trucks and tenders, and with double rectangular spokes for tenders and cars
Wheels are also furnished with Mansell retaining rings and with the bolt tire fastening, the weight varying accordingly

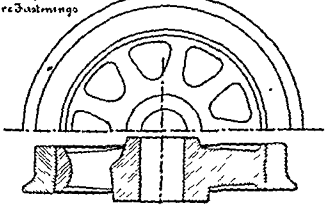
FIG 3.



PAGE, NEWELL & CO, BOSTON, MASS.
Wrought Iron Plate Center Wheel.

Wheels are furnished with either the Mansell retaining rings or the bolt tire fastening, as well as with the Brunswick tire fastening shown. Weights are about the same as for spoke wheels

FIG 4



WASHBURN CAR WHEEL CO, HARTFORD, CONN.
Cast-Iron Solid Spoke Center Wheel for Inside Bearings.
Center cast onto heated tire to fuse them together.

Diameter of Wheel in inches	Weight of Tire in lbs. FIGS 2, 5 ×2½"	3	4 (2")	Weight of Wheel with Tire in lbs. FIGS 2	3	4
26			302			675
28	330	330	320	575	575	750
30	350	350	340	610	610	775
33	390	390	375	680	680	875
36	430	430	425	760	760	[illegible]
42	500	500		950	955	
42 (5 ?)	600	600		1010	[illegible]	

REPORT ON STEEL-TIRED WHEELS.

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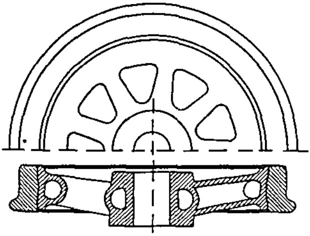
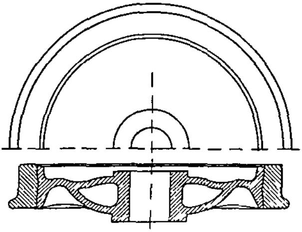
FIG 1



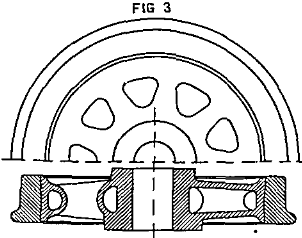
WASHBURN CAR WHEEL Cº HARTFORD CONN
Cast Iron Hollow Spoke Center Wheel for Outside Bearings
Center cast into heated tire to fuse them together

FIG 2



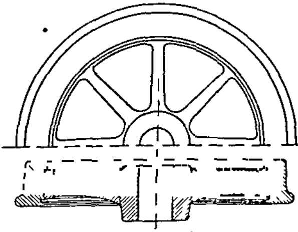
WASHBURN CAR WHEEL Cº HARTFORD, CONN
Cast Iron Double Plate Center Wheel for Outside Bearings
Center cast into heated tire to fuse them together

FIG 3



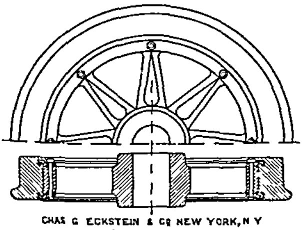
WASHBURN CAR WHEEL Cº, HARTFORD, CONN
Cast Iron Hollow Spoke Center Wheel for Inside Bearings
Center cast into heated tire to fuse them together

FIG 4



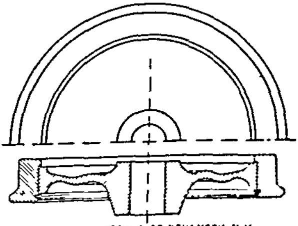
CHAS. G ECKSTEIN & Cº NEW YORK, N Y
ARBEL WHEEL
Wrought Iron Oval Spoke Center Wheel

FIG 5



CHAS G ECKSTEIN & Cº NEW YORK, N Y
ARBEL WHEEL
Wrought Iron Double Spoke Center Wheel

FIG 6



CHAS G ECKSTEIN & Cº NEW YORK, N Y
ARBEL WHEEL
Wrought Iron Corrugated [illegible] Center Wheel

Diameter of Wheel in inches.	Weight of 2½ in. Tire in lbs. FIGS						Weight of Wheel with tire in lbs. FIGS					
	1	2	3	4	5	6	1	2	3	4	5	6
24		[illegible]						500				
26		300	300					[illegible]	575			
28		320	320					[illegible]	[illegible]			
30	340	340	340				650	[illegible]	[illegible]			
33	375	375	375				[illegible]	[illegible]	[illegible]	[illegible] 725		
36		425						875				
42		500						[illegible]				

REPORT ON STEEL-TIRED WHEELS.

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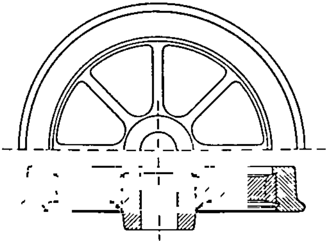
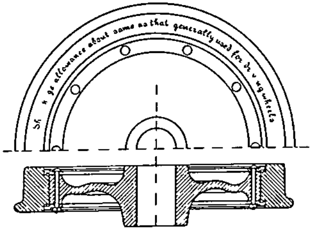
FIG 1



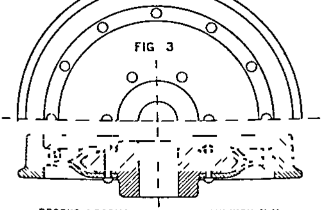
CHAS G ECKSTEIN & CO., NEW YORK, N Y
ARBEL WHEEL
Wrought Iron Rectangular Spoke Center Wheel

FIG 2



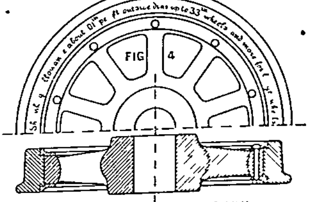
THOMAS PROSSER & SON NEW YORK N Y
KRUPP Nº 1 WHEEL
Wrought-Iron Cold Pressed Center Wheel with Wrought Iron Retaining Rings

FIG 3



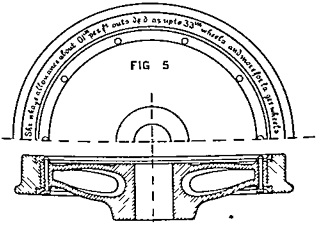
BROOKS LOCOMOTIVE WORKS DUNKIRK N Y
THURBER WHEEL
Plates are shrunk on hub and tire is shrunk on plates then drilled to gauge and all riveted together under hydraulic pressure

FIG 4



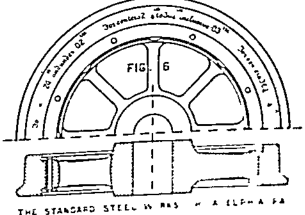
NATIONAL CAR WHEEL CO, DEPEW, N Y
Paris wheel
Cast iron center 1 steel tire 1 wrought iron retaining rings 2 bolts 10 nuts 10 Total parts 24

FIG 5



NATIONAL CAR WHEEL CO DEPEW N Y
Paris wheel
[illegible]

FIG 6



THE STANDARD STEEL WORKS [illegible]
[illegible]

Diameter of Wheel in inches	Weight of Tires in lbs FIGS 1 (22in)	2	3 (24in)	4	5	6 (22in)	Weight of wheel [illegible] FIGS 1	2	3	4	5	6		
										[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26									[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
28			362						672	[illegible]	[illegible]		[illegible]	[illegible]
30			380								[illegible]	[illegible]	[illegible]	[illegible]
33			4[illegible]0				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]			480					6[illegible]5						
42			[illegible]44											

REPORT ON STEEL-TIRED WHEELS.

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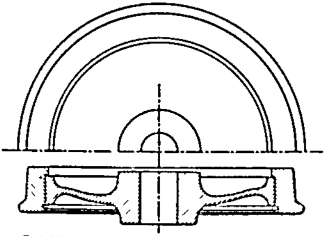
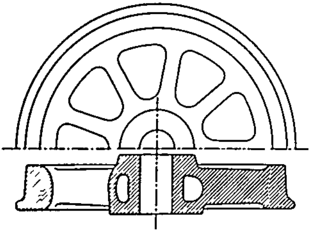
FIG 1.



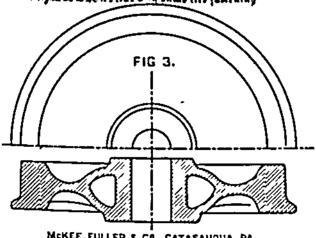
THE STANDARD STEEL WORKS, PHILADELPHIA, PA
Wrought Iron Plate Center Wheel
Wheel also made with Mansell retaining rings or with Gibson fastening
Number of parts the same as wheel Fig 6 PLATE LXXIX
Weighs 30 to 40 lbs less with same tire fastening

FIG 2.



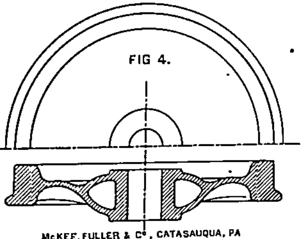
McKEE, FULLER & Co, CATASAUQUA PA
Cast Iron Spoke Center Wheel for Engine Trucks
Center is cast into heated tire to fuse them together

FIG 3.



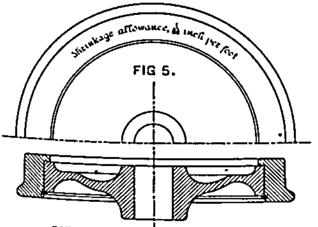
McKEE, FULLER & Co, CATASAUQUA, PA
Cast-Iron Plate Center Wheel for Engine Trucks
Center is cast into heated tire to fuse them together

FIG 4.



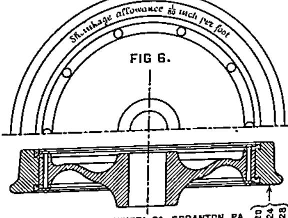
McKEE, FULLER & Co, CATASAUQUA, PA
Cast Iron Plate Center Wheel for Tenders and Cars.
Center is cast into heated tire to fuse them together

FIG 5.



BOIES STEEL WHEEL Co, SCRANTON, PA.
Wrought-Iron Plate Center Wheel with Gibson Fastening

FIG 6.



BOIES STEEL WHEEL Co, SCRANTON, PA
Wrought-Iron Plate Center Wheel
with Two Mansell Retaining Rings.

Number of parts:
28in & 30in wheels including 8 bolts & 8 nuts 20
33in " 36in " " 10 " 10 " 24
38in " " 12 " 12 " 28

Diameter of Wheel in inches	Weight of Tire in lbs FIGS						Weight of Wheel with Tire in lbs FIGS.						Weight of ring	Weight of fastenings
	1	2	3	4	5($2\frac{1}{2}$in)	6($2\frac{1}{2}$in)	1	2	3	4	5	6	5	6
24	30 to 40 lbs less than Wheel FIG 6 Plate LXXIX						30 to 40 lbs less than Wheel FIG 6 Plate LXXIX	550						
26								600						
28					345	315		670			641	622	6	52
30					400	370		700	700		727	701	7	56
33					440	405		780		780	823	801	8	64
36					485	450		880	880	880	929	907	9	70
38					520	480					1010	981	10	76

 PLATE LXXXI.

REPORT ON STEEL-TIRED WHEELS.

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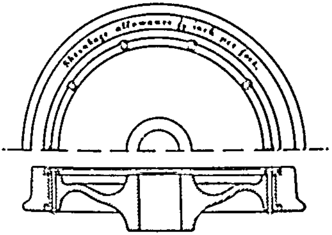
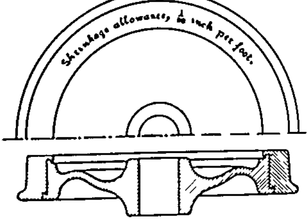
FIG. 1.

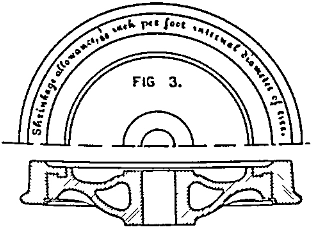


SOIES STEEL WHEEL C°, SCRANTON, PA
Wrought-Iron Plate Center Wheel with Single Retaining Ring.
Number of parts, same as wheel Fig. 6. PLATE LXXX
Also same total weight

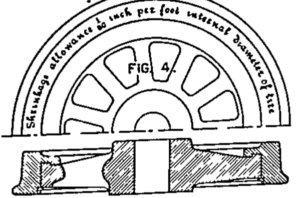
FIG. 2.



SOIES STEEL WHEEL C°, SCRANTON, PA
Wrought-Iron Plate Center Wheel with Integral Tire Lock
The integral lip on outside of tire is cold-rolled into the recess in center; this lip must be cut to remove tire.
Total number of Parts 2

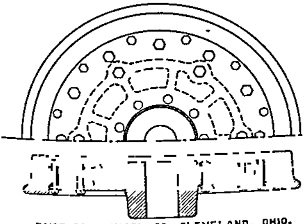


RAMAPO WHEEL FOUNDRY C°, RAMAPO, N Y
Snow Boltless Cast-Iron Plate Center Wheel for Tenders and Cars.
Number of parts. 3.



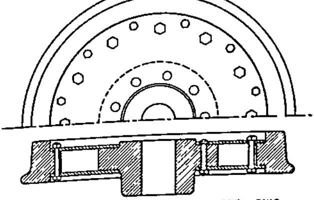
RAMAPO WHEEL & FOUNDRY C°, RAMAPO, N Y
Snow Boltless Cast-Iron Spoke Center Wheel
Number of parts 3

FIG. 5.



PAIGE CAR WHEEL C°, CLEVELAND, OHIO.
Engine Truck Wheels, 33in or Over Car Truck Wheels 36in or Over
Parts in engine truck wheel, including 39 bolts and 30 nuts 73.
Parts in car wheel including 39 bolts and 39 nuts 82.
Plates pressed into place at from 90 tons to 110 tons pressure

FIG 6



PAIGE CAR WHEEL C°, CLEVELAND, OHIO
Engine Truck Wheels under 33in Car Truck Wheels under 36in
Parts in engine truck wheel including 33 bolts and 24 nuts 61
Parts in car wheel, including 33 bolts and 33 nuts 70
Plates pressed into place at from 90 tons to 110 tons pressure

Diameter of Wheel in inches	Weight of Tire in lbs FIGS 1	2 (2½ in)	3	4.	5 (2½ in)	6 (2½ in)	Weight of Wheel with Tire in lbs FIGS 1	2	3	4	5 Car Wheel	5 Engine Truck Wheel	6 Car Wheel	6 Engine Truck Wheel
24	Same as Wheel FIG 6 Plate LXXX					380	Same as Wheel FIG 6 Plate LXXX						636	654
26						390							660	683
28		345	362	362		445		645	637	692			738	768
30		400	395	395		475		730	724	755			785	828
33		440	443	443	530	530		830	876	843		935	888	
36		486	482		565			935	962		1041	1060		
38		520	530		595			1020			1142			
41					640						1234			
42					660						1284			

REPORT ON STEEL–TIRED WHEELS.

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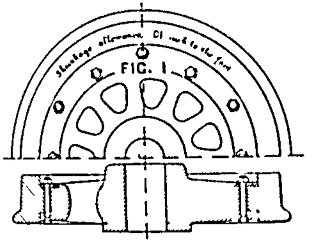
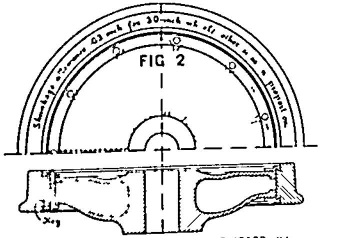
FIG. 1



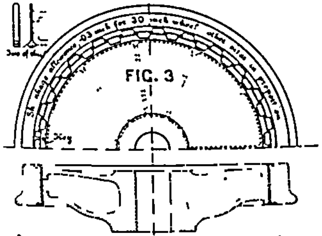
PAIGE CAR WHEEL CO., CLEVELAND, OHIO.
Cast Iron Spoke Center Wheel
Parts, including 12 bolts and 12 nuts 27

FIG 2



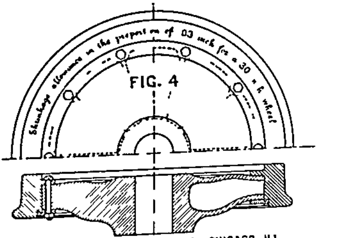
ALLEN PAPER CAR WHEEL CO., CHICAGO, ILL
No 8 Cast Center Wheel with Mansell Rings
Number of parts 4 besides bolts and nuts which are from 7 to 11 each according to size of wheel and 3 keys, making total number of parts from 21 to 29

FIG. 3



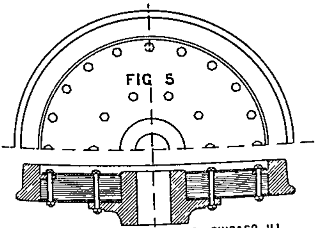
*** ALLEN PAPER CAR WHEEL CO., CHICAGO, ILL**
Cloud Boltless Wheel
Number of parts including 2 liners and 2 keys 6
Made also in 3 parts without keys and with one liner

FIG. 4



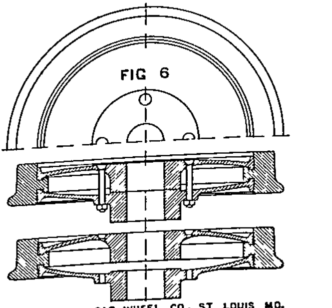
ALLEN PAPER CAR WHEEL CO, CHICAGO ILL
No 11 Cast Center Wheel with one Mansell Retaining Ring for Tenders and Cars
Number of parts 3 besides bolts and nuts which are 10 each for 33 inch and 11 each for 36 inch and 38 inch wheels making total parts respectively 23 & 25

FIG 5



ALLEN PAPER CAR WHEEL CO., CHICAGO, ILL
No 1 PAPER WHEEL
For Engine Trucks Tenders and Cars.
Number of parts 4 besides bolts and nuts which vary from 21 each to 30 each making total number of parts 46 to 64.
Center is .01 inch greater diameter than bore of tire and is pressed into place by hydraulic pressure

FIG 6



STEEL TRUSS CAR WHEEL CO, ST LOUIS MO.
Number of parts 3 besides 4 bolts and 4 nuts, total parts 11 Dishes are forced into place by hydraulic pressure of 90 to 110 tons and then bolted together

Diameter of Wheel in inches	Weight of Tires in the FIGS 1 (2½")	2 (2½")	3	4 (2½")	5 (2½")	6	Weight of Wheel with Tire in the FIGS 1	2	3	4	5	6
26	385	310			365		722	622	[illegible] the same as No 8 wheel FIG 2		643	
28	440	322			385		794	689			697	
30	470	352			442		905	758			766	
33	520	390		431	476		1030	818		869	843	760
36	555	434		475	539		1142	954		964	961	
38	585			500	582		1226			1071	1039	
42					621						1165	